SECTION 3.0 – ADDITIONAL SITE-SPECIFIC RESOURCE INFORMATION

3.0 ADDITIONAL SITE-SPECIFIC AQUATIC RESOURCE INFORMATION

3.1 Borings to Confirm Depth to Bedrock and Determine Side Slope Stability

The New Bedford/Fairhaven Harbor DEIR provided a detailed analysis of alternative disposal sites for the disposal of unsuitable dredged materials (UDM)(MAGUIRE, 2002). The preferred alternative disposal sites presented in the DEIR consist of two confined aquatic disposal (CAD) sites within New Bedford/Fairhaven Harbor (Harbor). The two CAD sites are referred to as Channel Inner (CI) and Popes Island North (PIN) (Figure 3-1). Phase I exploratory geotechnical investigations were conducted for the DEIR (Maguire, 2002). Geotechnical borings and other geophysical studies were undertaken at each of the potential CAD locations (Maguire, 2002). Comments on the DEIR concurred with recommended additional site-specific Phase II geotechnical borings to obtain a greater level of confidence in the depths to bedrock for this FEIR. The new Phase II borings also provided sediment characteristics for preliminary engineering including side-slope stability of (CAD) cells of the CI and PIN resource areas (Maguire, 2003, and see Appendix A).

Note: The FEIR distribution capacity is based on the geotechnical characteristics of the CAD areas as a conceptual basis for long-term use of the CADs. Specific CAD sites and location within the area of the preferred alternative will be determined by the specific dredging program developed by New Bedford and Fairhaven.

3.1.1 Goal

The goal of the additional borings was to confirm depths to bedrock and to determine CAD cell side slope stability. Specific depths to bedrock were established to provide a more accurate estimate of the potential CAD cell capacities. Geotechnical analysis of sub-aqueous soil samples from the four additional borings provided sediment engineering properties to support the preliminary design of stable and constructible CAD cell side-slopes (Maguire, 2003, and see Appendix A).

3.1.2 Description of Study

The two proposed CAD cell sites are located approximately ½-mile apart (Figure 3-1). The CI site has an area of approximately 90-acres (Figure 3-2) and is the more southerly area. The PIN site, with an area of approximately 80-acres, is the more northerly area (Figure 3-3). Fieldwork consisted of integrated geotechnical and geophysical investigation efforts. Phase I geophysical seismic refraction surveys in the DEIR were the primary investigatory tool used to develop the study area bedrock surface database and establish preliminary CAD cell design parameters. These geophysical surveys were used to assist in the appropriate location of Phase II marine boring explorations contained in this FEIR. Four Phase II borings were drilled between October 15 – 23, 2002 at predetermined locations within the two sites studied (Figures 3-2, 3-3). The boring locations were selected to verify maximum/minimum bedrock elevations or were located in areas of "low confidence" bedrock interpretation.

The Phase II geotechnical drilling program was conducted with a barge mounted drill rig in the Harbor. Samples of soil were collected during the drilling program using a split-spoon sampler. Rock-core samples were collected from the borings using a diamond-bit rock core barrel. The borings were performed in areas that supplement previously collected geotechnical information. Phase II borings also provided representative sediment samples and sampling standard penetration test (SPT) data, from mudline to bedrock depth, necessary for sediment engineering property estimates. The geotechnical laboratory program was undertaken to assist in sediment strata differentiation and sediment engineering property development. The laboratory program was also designed to provide a sediment physical property database for this and subsequent State-wide CAD cell design and construction feasibility assessments.

Site Area	Marine Borings	
	Phase II October 2002	Total Borings
CI	NBH – 9, 10 and 11	3
PIN	NBH - 8	1

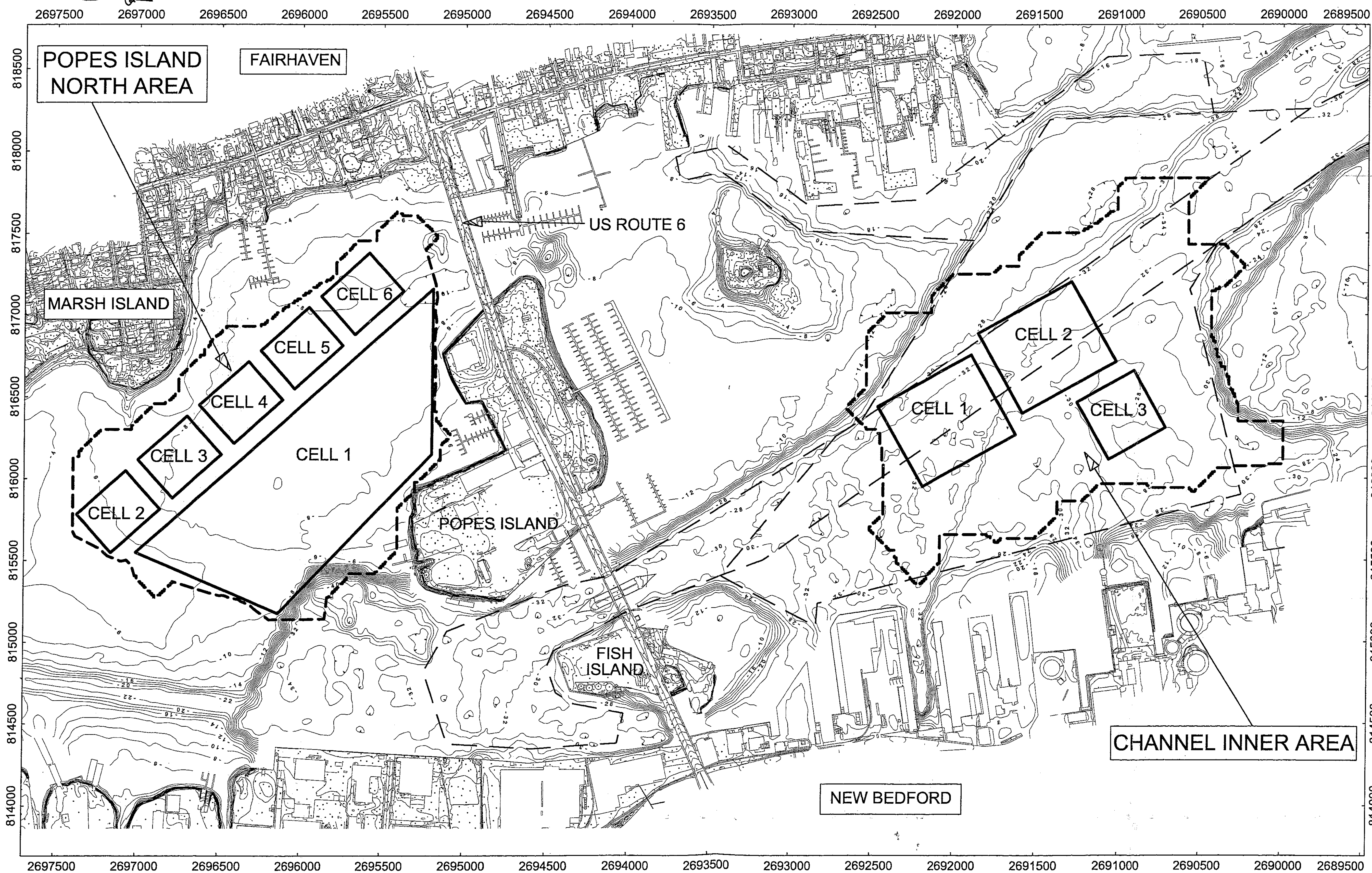
The geophysical program used data from the four additional Phase II borings to recalibrate the existing bedrock profile model for greater confidence (Apex, 2003). Initial depth-to-bedrock information was re-run using the final models from 2001 as a starting point. Based on the comparisons between the existing models and the new depth to bedrock elevation information gained through the 2002 drilling program, various lines were re-analyzed. More refined geophysical bedrock profile modeling recalibrated with supplemental data was the most cost efficient approach to produce high resolution bedrock profiles of these 90- and 80-acre sub-aqueous sites. It should be noted that project borings are widely spaced and only general trends in subsurface conditions are revealed. Due to the wide spread boring location spacing they were integrated with area wide geophysical exploratory techniques.

3.1.3 Results

The Phase II geotechnical program borings of the two proposed CAD cell sites revealed similar geologic stratigraphy, from mudline down:

- Surficial organic sediments, Organic Silt and Peat, are geologically recent, Holocene Era, deposits.
- The Interbedded silts, sands, and sands and gravels with occasional boulders, are complex bedded Glacial-Drift Pleistocene Age deposits composing the bulk of the stratigraphic column.
- The deepest Glacial Till stratum is generally dense, thin and boulder laden. The Glacial Till stratum was formed by direct glacial ice-contact during the Pleistocene Age.

The bedrock, Gneissic Granite (Alaskite), is surficially fractured and observed to be in a fresh to slightly weathered condition. Of note are the extensive Organic Silt and Peat deposits observed in boring NBH-1, located at the north end of the Popes Island North site. During initial cell



NOTES:

1. Base Plan of the New Bedford Harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).

POPES ISLAND NORTH AND CHANNEL INNER CAD CELL SITE LOCATIONS

0 600 1200 1800

SCALE: 1"=600' FEET

LEGEND

- FEDERAL NAVIGATION CHANNEL, ANCHORAGE AND MANEUVERING AREA LIMITS (CHANNEL INNER AREA)
- 2 FOOT BATHYMETRIC CONTOUR
- PROPOSED CAD CELL CONFIGURATION
- LIMITS OF GEOPHYSICAL/GEOTECHNICAL EXPLORATION AND INTERPRETATION

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Foxborough, Massachusetts 02035

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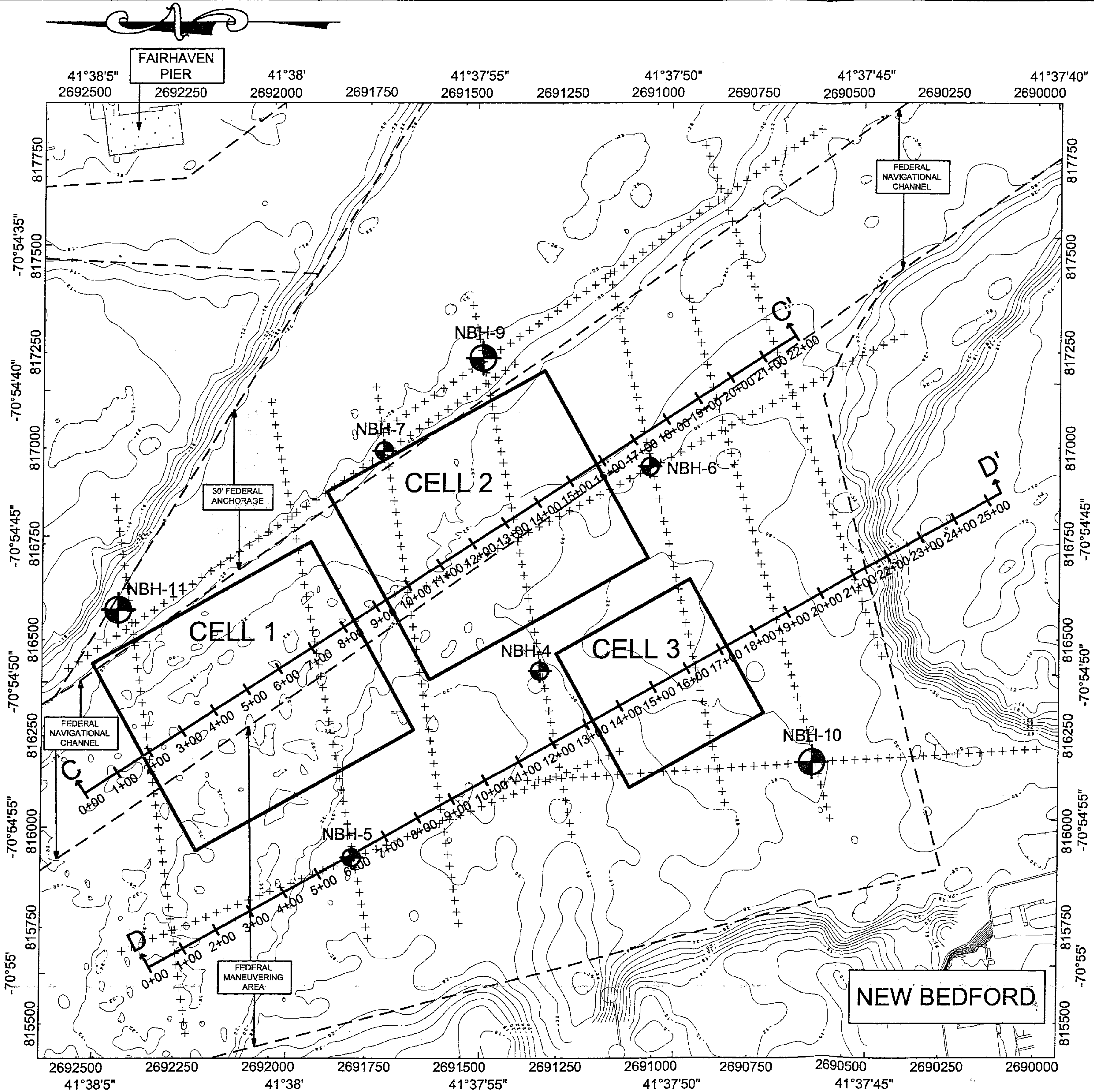
FIGURE 3-1. POPES ISLAND NORTH AND CHANNEL INNER CAD CELL SITE LOCATIONS

PROJECT NO.: 16454	
DESIGNED BY: ---	
DRAWN BY: ---	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	



NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
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LEGEND

NBH-7 — PHASE I PROJECT BORING LOCATIONS

NBH-10 — PHASE II PROJECT BORING LOCATIONS

FEDERAL NAVIGATION CHANNEL, ANCHORAGE AND MANEUVERING AREA LIMITS

GEOPHYSICAL SURVEY LINES

2 FOOT BATHYMETRIC CONTOUR

PROPOSED CAD CELL CONFIGURATION

C — C' (0+00 1+00 2+00 3+00 4+00) PROFILE LOCATION WITH STATIONING

3. SCALE:

0 300 600 900

SCALE: 1"=300' FEET

CHANNEL INNER CAD CELL CONFIGURATION SUBSURFACE PROFILE AND EXPLORATION LOCATION PLAN

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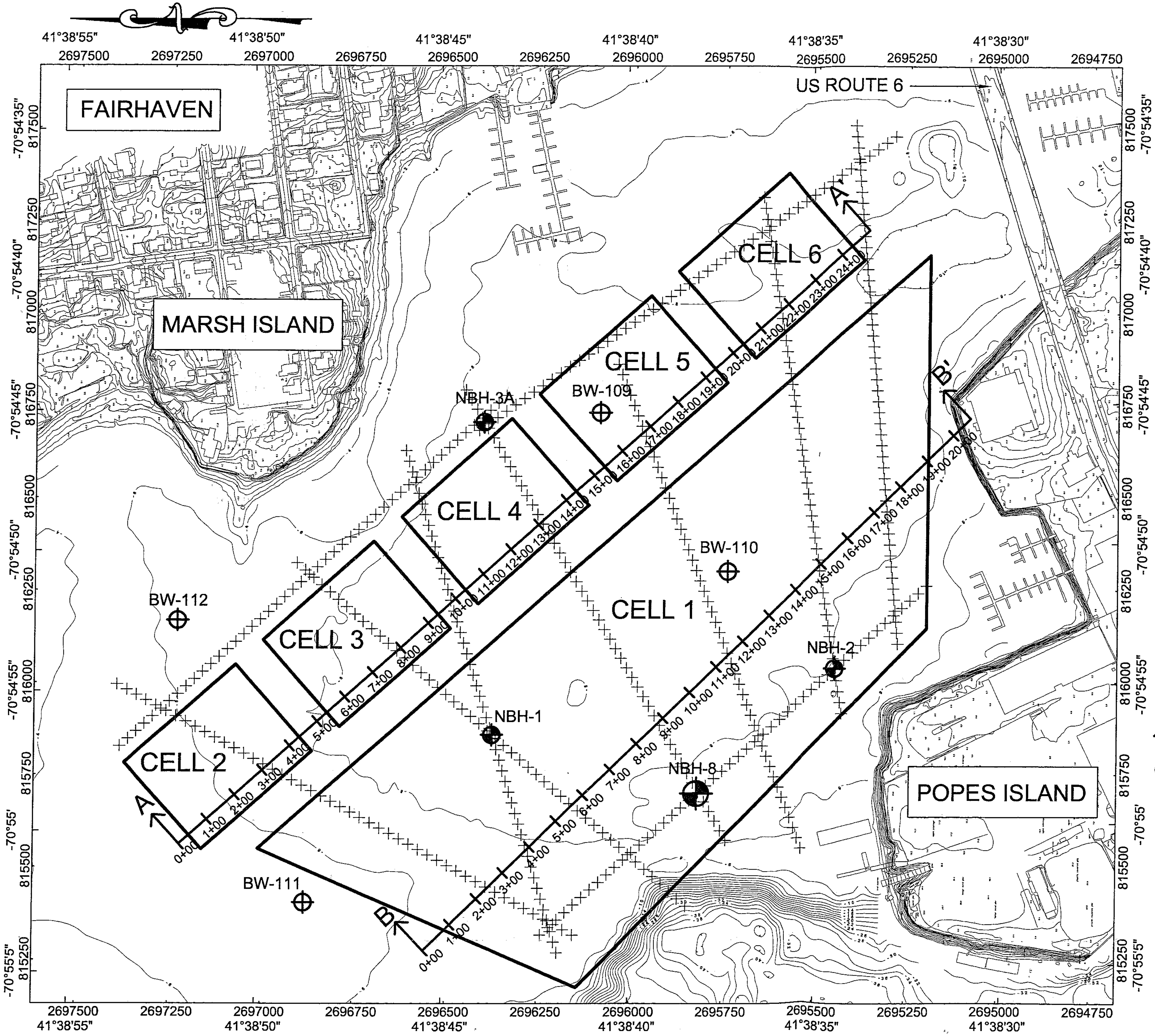
FIGURE 3-2. CHANNEL INNER CAD CELL CONFIGURATION SUBSURFACE PROFILE AND EXPLORATION LOCATION PLAN

PROJECT NO.: 16454	
DESIGNED BY: ---	
DRAWN BY: ---	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	



POPES ISLAND NORTH
CAD CELL CONFIGURATION
SUBSURFACE PROFILE AND EXPLORATION LOCATION PLAN

NOTES:

1. Base Plan of the New Bedford Harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).

LEGEND

NBH-1 — PHASE I PROJECT BORING LOCATIONS

NBH-8 — PHASE II PROJECT BORING LOCATIONS

BW-110 — EBASCO SERVICES 1988 STUDY BORING LOCATIONS

GEOPHYSICAL SURVEY LINES

1 FOOT BATHYMETRIC CONTOUR

PROPOSED CAD CELL CONFIGURATION

A A' 0+00 1+00 2+00 3+00 4+00 PROFILE LOCATION WITH STATIONING

3. SCALE:

0 300 600 900

SCALE: 1"=300' FEET

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FIGURE 3-3. POPES ISLAND NORTH CAD CELL CONFIGURATION SUBSURFACE PROFILE AND EXPLORATION LOCATION PLAN

PROJECT NO.: 16454	
DESIGNED BY: ---	
DRAWN BY: ---	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	

dredging, the organic sediments are the least stable and exhibit the shallowest stable slope angles. The most prominent stratigraphic feature, the Interbedded Glacial Drift and the deepest sediment stratum, the Glacial Till, are observed to contain boulders, which will have to be addressed by the dredging management plan. The Glacial Drift is thought to contain only occasional boulders; while the more limited thickness Glacial Till significantly more. It is probable that cell dredging will not extend significantly into the Glacial Till stratum, dependent upon the defined Till limits.

For the Phase II geophysical program profiles generated from the data indicated that the bedrock character in both areas of interest is irregular, and marked by undulations of the bedrock surface (Figure 3-4). The results of the re-interpretation of the refraction data are best conveyed as contoured surface maps of the bedrock as determined from the interpreted seismic data. Figures 3-5 and 3-6 depict the results of the seismic data interpretation for CI and PIN area, respectively. The figures display the inferred top of bedrock surface as determined from the seismic refraction data as a color-coded contour elevation (referenced to NGVD29), in order to aid in the identification of trends in the surface (i.e., blue areas are deeper and red/pink/orange areas are shallower).

The “highest” bedrock surface elevation noted in the CI area is in the range of minus 35 feet (NGVD29). The “lows” in the bedrock topography, noted from the data within the possible CAD footprint are in the minus 66-foot range (NGVD29). The mean elevation of the bedrock surface in the CI area is minus 52-foot (NGVD29) (See Figure 3-5). The “highest” bedrock surface elevation noted in the PIN area is in the range of minus 28 feet (NGVD29). The “lows” in the bedrock topography, noted from the data within the possible CAD footprint are in the minus 95-foot range (NGVD29). The mean elevation of the bedrock surface in the Popes Island North area is minus 66 feet (NGVD29) (See Figure 3- 6).

Data collected in the CI revealed potential faulting or fracturing that trends north to south through the center of the area also affected seismic velocities and the models calculated using these velocities. Data collected in the PIN proved a high confidence indicating sound bedrock surface. Adding to the confidence in this area, is supporting seismic data northwest of the survey area (Foster Wheeler, 2001).

3.1.4 Summary

The Phase II geotechnical program determined that both the CI and PIN areas have sediment engineering properties to support the preliminary design of stable and constructible CAD cell 1V: 3H side slopes. Also, the absence of apparent bedrock precipice formations that might restrict CAD cell capacity restrictions was clarified. More refined depth of sediment from mudline to bedrock information helped define CAD cell capacities for CI and PIN. The estimated capacity for UDM is approximately 150,000 cubic yards (cy) at CI and approximately 2,050,000 cy at PIN.

The CI site is an area of uniformly shallow sediment depth. As a result, even a small project CAD cell would take up a large surface area making a small project CAD cell quite large in plan-area. This configuration results in a relatively large required total volume of sediment handled in relation to the volume of space created for contaminated sediment. The presence of the federal navigation channel, maneuvering and anchorage areas further complicate this area.

The PIN site typically exhibited shallower water and deeper sediment depths. In the PIN site, accommodation for five moderate volume dredge projects, ±50,000 cy each, as well as a large volume dredge project, ±1,800,000 cy, fits well with revealed subsurface conditions. The relatively shallow sediment depths along the area's eastern, Fairhaven, edge favors a moderate project cell approach, while the deeper sediment depths along the western bedrock valley, adjacent to Popes Island favors a large project cell approach. If moderate projects are initially considered for the PIN site, the potential for a dredge material quantity to fit within the eastern, shallow cell and shallow water depth area should be considered for specific project estimates. In addition, initial moderate project time estimates should reflect the use of smaller less efficient but more mobile equipment. Greater detail on CAD cell development is contained in Section 3.3 *Preliminary CAD Cell Configuration and Construction Planning.*

3.2 Comparative Dredged Materials Options

The DEIR presented discussions on a great number of UDM disposal options for dredged materials generated from Harbor maintenance before arriving at the preferred alternative CAD cells CI and PIN that are evaluated for the preferred alternative in this FEIR. Upland and aquatic disposal categories were thoroughly explored and evaluated. The off-site upland disposal was researched for the DEIR (Maguire, 2002). The process to prepare dredged material for final upland disposal or reuse involves the following primary site functions: off-loading; material screening; lime treatment; soil amendment; and transfer to disposal/reuse site (DEIR section 4.0). The cost for upland disposal ranges from $62 - $333/cy for silty UDM that is not suitable as final cover for landfills.

Aquatic disposal options for Harbor UDM other than the preferred alternative CAD cells, included disposal in traditional offshore dumping sites and subsequently capping the UDM with SDM. The hydrodynamic conditions for this remedy must be depositional, so that capping materials are not eroded over perpetuity thus chancing recontamination of the environment. Aquatic disposal options considered in the DEIR included the Buzzards Bay Disposal Site (BBDS) and West Island disposal area. These locations among others did not pass screening of the alternatives in the DEIR (Maguire, 2002, and see Section 4.0).

EPA has made a commitment to dispose of Harbor sediment containing very highly elevated "actionable levels" of contamination. In 1983 the EPA declared an area that has been defined as approximately 18,000 acres surrounding and including the Harbor as The New Bedford Harbor Superfund Site (EPA, 1998). In 1998 the EPA planned to construct four shoreline Confined Disposal Facilities (CDF) along the Upper Harbor shoreline. These CDFs were to be reconstructed coastal land features. The design of these CDFs included installation of permanent steel bulkheads set off the existing shoreline and back filling shore-side voids with contaminated materials then capping with clean materials to prevent recontamination with the environment. In 2002, the EPA issued formal additional information and a refined cleanup approach for the upper and lower Harbor. The new information eliminates a 17-acre CDF and replaces this shoreline

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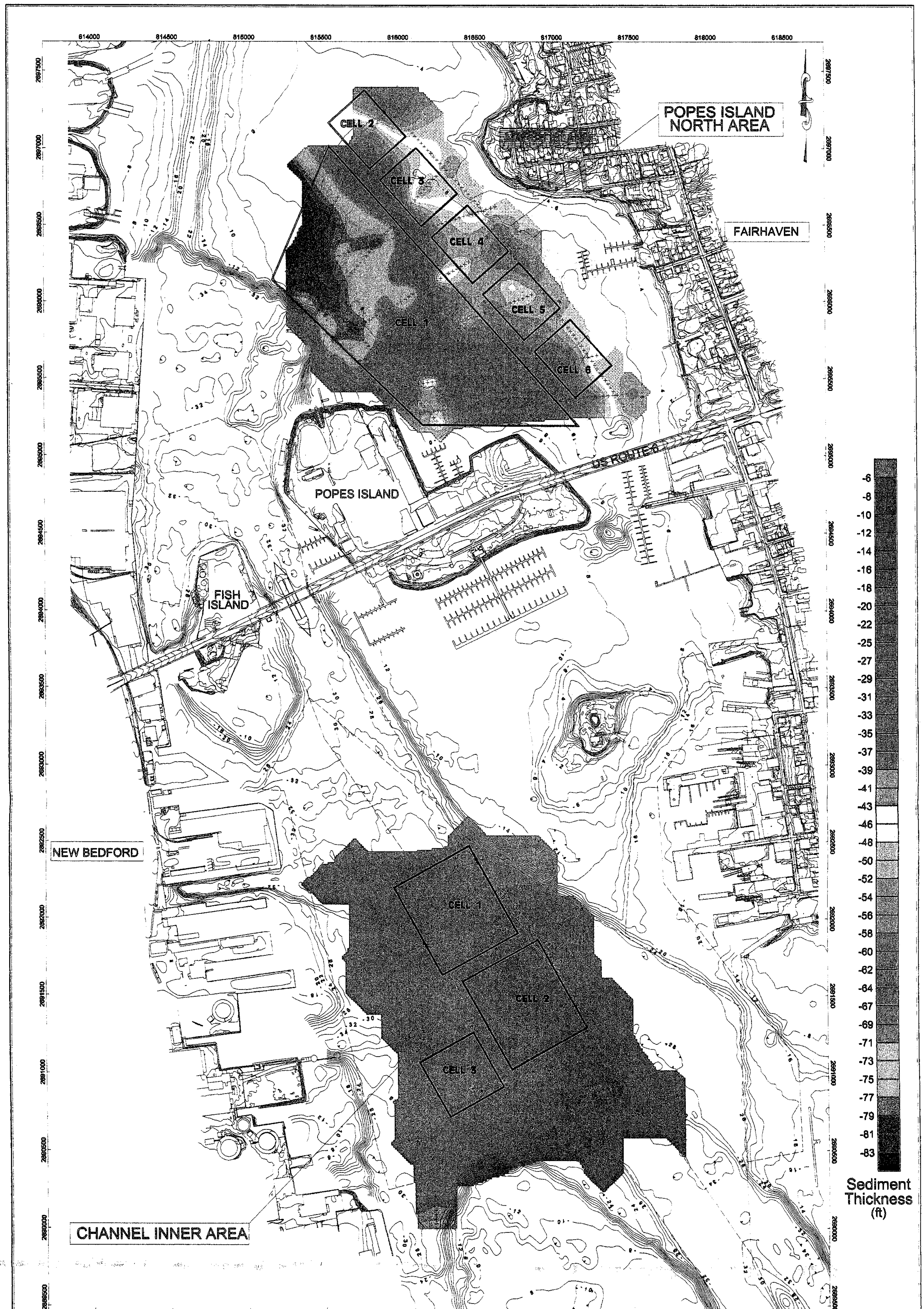

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).
3. Sediment Thickness Calculated as the Difference Between Bedrock and Mudline Elevations.

LEGEND

- FEDERAL CHANNEL, ANCHORAGE AND MANEUVERING AREA
- 2 FOOT BATHYMETRIC CONTOUR
- HYDROPHONE LOCATION
- PROPOSED CAD CELL CONFIGURATION

FIGURE 6 - SEDIMENT THICKNESS MAP
CHANNEL INNER & POPES ISLAND NORTH AREAS
SEISMIC REFRACTION - REVISED MODEL

NEW BEDFORD HARBOR
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

REV.	DESCRIPTION	BY	DATE
1.	POSSIBLE CAD CONFIGURATION	TDM	05/05/03

SCALE:	DRAWN:	DESIGN:	CHECKED:
	TDM	TDM	JAB

0 350 700 1050
1" = 350' SCALE FEET

PROJECT NO.: 16454	NEW BEDFORD/FAIRHAVEN HARBOR DMMP FEIR
DESIGNED BY: - - -	
DRAWN BY: - - -	FIGURE 3-4. HARBOR CAD SITES
CHK'D BY:	SEDIMENT THICKNESS
DATE: 06/02/03	TO BEDROCK SURFACE PLAN
SCALE: AS NOTED	

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MARK	DATE	DESCRIPTION

Drawing File: N:\PROJECTS\CIVIL\GEOTECH\APEX ENGINEERING 5-8-03\Presentation Drawings\HALF-SIZES 8-27-03\1545'CFC104.dwg Plotted: Sep 15,2003-8:47am By: Whovey

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83). Vertical Datum referenced to NGVD29.
3. Boring information and position supplied by The Maguire Group.

LEGEND:

- SEISMIC CALIBRATION BORING (MAGUIRE)
- FEDERAL CHANNEL, ANCHORAGE AND MANEUVERING AREA LINE
- HYDROPHONE LOCATION (PHONE NUMBER & BEDROCK ELEVATION INDICATED)
- 2' BATHYMETRIC CONTOUR
- PROPOSED CAD CELL EXTENT
- PROFILE LOCATION

1" = 150' SCALE 0 150 300 450 FEET

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FIGURE 3-5. CHANNEL INNER BEDROCK SURFACE PLAN

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PROJECT NO.:	16454
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CHK'D BY:	
DATE:	06/02/03
SCALE:	AS NOTED

MARK	DATE	DESCRIPTION

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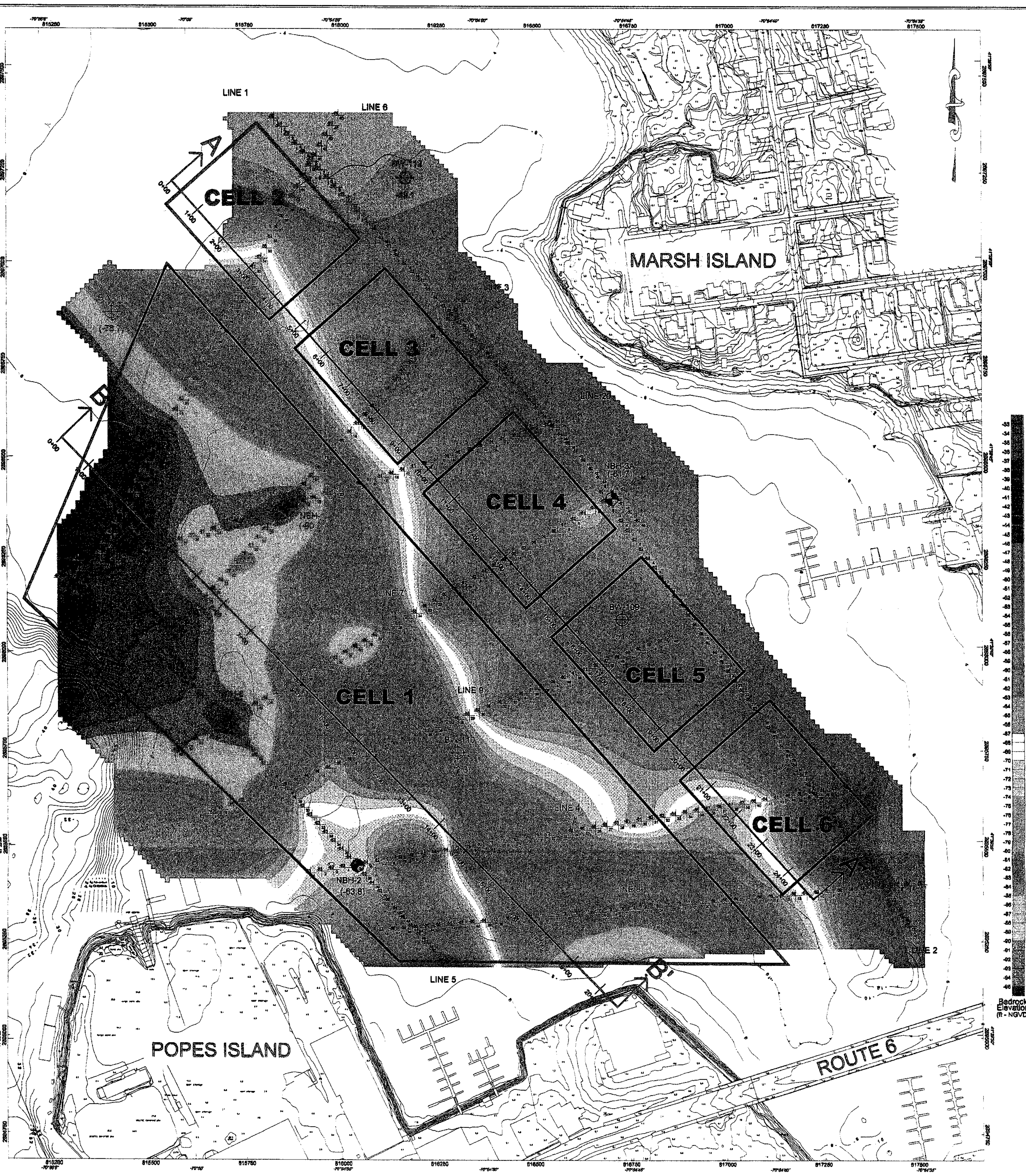

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001,Referenced to the 1983 North American Datum (NAD83). Vertical datum NGVD29.
3. Boring information and position supplied by The Maguire Group.

LEGEND

- SEISMIC CALIBRATION BORING
- EBASCO BORING (APPROXIMATE LOCATION)
- HYDROPHONE LOCATION (PHONE NUMBER & BEDROCK ELEVATION)
- 1' BATHYMETRIC CONTOUR
- PROPOSED CAD CELL EXTENTS
- PROFILE LOCATION

1" = 150'

0 150 300 450
SCALE FEET

PROJECT NO.: 16454	
DESIGNED BY:	
DRAWN BY:	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	

NEW BEDFORD/FAIRHAVEN HARBOR DMMP FEIR

FIGURE 3-6. POPES ISLAND NORTH BEDROCK SURFACE PLAN

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MARK	DATE	DESCRIPTION

disposal with off-site upland disposal (EPA, 2002). This change reflects considerable savings to the Agency clean-up cost. Still the estimate for the latest change equates to approximately $400/cy to dispose of the actionable contaminated Harbor sediment for perpetuity (EPA, 2002).

3.3 Preliminary Cad Cell Configuration And Construction Planning

The DEIR provided the basis for conceptual engineering for CAD cells at the preferred alternatives CI and PIN sites. The FEIR distribution capacity is based on the geotechnical characteristics of the CAD areas as a conceptual basis for long-term use of the CADs. Specific CAD sites and locations within the area of the preferred alternative will be determined by the specific dredging program, developed by New Bedford and Fairhaven. In response to the Draft EIR Certificate, the Secretary called for site-specific information supportive of a Preferred Alternative Cad cell management plan. This Certificate states that if the site-specific information indicates that the preferred alternative, in whole or part, is not suitable, the FEIR will provide the same level of information on any alternative site or methodology that might be chosen. Information derived from the latest geotechnical and geophysical studies that the FEIR was applied to this preliminary CAD cell configuration and construction planning to attain a higher level of management confidence. Application of the latest geotechnical and geophysical findings provided a lower level of management confidence for CI and conversely a higher level of management confidence in PIN (section 3.1 of this FEIR). Also, after the publication of the DEIR, the NBHDC expressed particular interest to include small moderate capacity CAD cells of approximately 50,000 cy UDM capacity in the overall CAD cell planning horizon.

3.3.1 Preferred Alternatives CAD Cell Configurations and Construction Planning

Distances between CAD cells at each site were maintained at 100-feet for construction efficiency and cell stability considerations. In calculating the volume of each cell, a slope of 1Vertical: 3Horrizontal (1V: 3H) was determined to be suitable to produce stable and constructible cell side slopes. This geotechnical evaluation was based upon a review of: boring and sediment laboratory test data, examination of sediment samples, geophysical interpretations, and qualified geotechnical research and experience in the New England area with similar sediment profiles. The stability of cell side slopes is in part a function of exposure time to environmental and operational forces.

Table 3-1, Estimated Sediment Engineering Properties, summarizes estimated sediment engineering properties and cell side slopes for preliminary CAD cell design. In the short-term, repetitive forces imposed by dredging operations, tidal current and wave loadings as well as storm forces will slightly degrade initially stable submarine slopes. In the long-term, cell side slopes need to be stable enough to maintain the full depth integrity of sequestered contaminated organic sediments that have relatively weak structural properties. The recommended 1V: 3H CAD cell side slopes assumed the variety of sediment types involved as well as a reasonably short-term, single season, exposure period, i.e., CAD cells would likely be dredged and backfilled in one season.

Final cell capping may occur during the subsequent season to allow the confined sediments time to consolidate and gain structural stability. (See discussion in Section 8.0, Dredging Management Plan.) A 10-foot buffer was maintained between proposed bottom of CAD cell and the average bedrock surface within the CAD cell footprint. This buffer accounts for inaccuracies in the defined bedrock surface, variations in the actual bedrock surface and further maintains several feet of dense sediment buffer between cell contained contaminants and possible fractured bedrock surfaces. Cell capping thickness determination for CAD cells requires consideration of bioturbation, consolidation, erosion, operational, and chemical isolation as design parameters (USACE, 1998).

The objective of capping the contaminated dredged materials in NBH CAD cells is to adequately isolate the UDM from the environment (Palermo, et al., 1998). A three-foot CAD cell cap was introduced as conceptual in the DEIR. Equivalent caps have been engineered for the CAD cells of Boston Harbor Navigation Improvement Project (BHNIP), Providence River and Harbor Maintenance Dredging Project (PRHMDP) and Newark Bay Confined Disposal Facility (NBCDF and USACE, 1995 and USACE, 2001 and PANYNJ, 1998). Post-dredge monitoring of CAD cells of BHNIP shows effective recolonization of opportunistic macrobenthic species within one year (ENSR, 2001). An extremely conservative four-foot CAD capping thickness was assumed for the CAD cells in this particular Harbor due to the highly elevated level of known contaminants (ENSR, 2002). Even though much of the contaminated dredged material expected to be sequestered in the PIN CAD cell is below EPA actionable levels, the four-foot conservative capping layer has been planned for environmental safety (EPA, 1998).

3.3.1.1 Channel Inner Area CAD Cells

After investigating the potential storage volume within the CI area, it is apparent that the shallow bedrock and general location of the proposed cells may severely limit the potential capacity in this area. Volumes were calculated assuming three cells in the CI area. All three CAD cells were designed to accommodate approximately 50,000 cubic yards of material. Figure 3-2 shows the cell configuration.

In addition, the proposed CI CAD cells are located within the federal channel and associated maneuvering /anchorage area. In order to account for future dredging activities, which may disturb the suitable material cap, an additional contingency of three (3) feet was planned. This additional contingency is expected to be either an additional cap thickness of three (3) feet, or a depressed surface (i.e., leaving the final grade 3-feet below required depths). This extra operational compensation was added to protect the cap from being dredged as part of ongoing maintenance dredging during normal harbor/port operations. For each CAD cell, total storage capacity equals the volume of suitable material expected to be placed.

Figure 3-7 below shows an estimate of the division of the available volume for the CI area. Table 3-2 below summarizes the calculations for the CI area.

New Bedford/Fairhaven Confined Aquatic Disposal Cell
Feasibility Study
Estimated Sediment Engineering Properties

Stratum	SPT Value[1] N_{avg}	N_{corr}	Avg. Stratum Thickness (Ft.)	Atterberg Limits[2] W_n	LL	PL	PI	Organic Content (%)[3]	Grain Size Components (%)[4] Silt/Clay	Sand	Gravel	Unit Weight (lb/ft^3)[5] γ_{total}	$\gamma_{bouyant}$	γ_{dry}	Unified Classification[6]	Effective Stress Parameters[7] c	ϕ	Recommended Cell Side Slope (Vert:Hor)[8]
Popes Island North																		
Organic Silt (O)	WOR	WOR	17	64	73	29	44	5.6	62	37	1	110	46	66	OH,OL	0	26°	1 : 3
Peat (P)	WOR	WOR	4	206	253	160	93	45.7	94	6	0	95	31	25	P_t, OL	0	26°	1 : 3
Interbedded Glacial Drift (I)	20	18	49	Granular - Non Plastic				NA[9]	17	68	15	126	62	100	SW, SM, SP, ML	0	30°	1 : 3
Glacial Till (T)	40	30	5	Granular - Non to Low Plasticity				NA	17	43	40	135	71	120	SM, GC, GM	0	38°	1 : 3
Channel Inner																		
Organic Silt (O)	WOR	WOR	5	69	54	28	26	4	59	33	8	110	46	66	OH, OL	0	26°	1 : 3
Interbedded Glacial Drift (I)	10	16	16	Granular - Non Plastic				NA	14	66	20	124	60	97	SW, SM, SP	0	30°	1 : 3
Glacial Till (T)	60	60	6	Granular - Non to Low Plasticity				NA	14	51	35	135	71	120	SM, SP	0	38°	1 : 3

1 N_{avg} = average stratum Standard Penetration Test (SPT) value per ASTM D 1586, N_{corr} = average stratum SPT value corrected for overburden pressure.
2 Wn = average natural sample water content per ASTM D 2216 - 98; average Atterberg Limits: LL, PL and PI = Liquid Limit, Plastic Limit and Plasticity Index per ASTM D 4318 - 98 (Method A).
3 Average Organic Content % per ASTM D 2974-87 (Method B & C).
4 Stratum differentiation into average grain size components: Fines, Sand and Gravel are as per the Unified Classification System. The Interbedded Glacial Drift and Glacial Till strata contain occasional boulder sized materials. Refer to item 6 below.
5 Estimated stratum average unit weight: total, bouyant and dry.
6 Unified Soil Classification System per ASTM D 2487-90.
7 Estimated average effective stress sediment parameters: c = cohesion, ϕ = friction angle, based upon SPT and grain size correlation and regional experience.
8 Recommended CAD Cell side slope for preliminary design, assumed short term single season dredge/backfill exposure.
9 NA = Not available, no organics present.

Table 3-1. Estimated Sediment Engineering Properties

Table 3-2. Volume Calculation summary for the Channel Inner Area CAD configuration shown in Figure 3-7**.**

Cell	Average Bedrock Elevation	Average Bathymetric Elevation	Sediment Thickness	Available Dredge Depth	Total Dredged Volume	Total Storage Capacity
1	-57 ft	-31 ft	**26 ft**	16	**213,000 CY**	**48,500 CY**
2	-57 ft	-31 ft	**26 ft**	16	**213,000 CY**	**48,500 CY**
3	-58 ft	-28 ft	**30 ft**	20	**111,900 CY**	**55,750 CY**

- **Average Bedrock Elevation –Average Bathymetric Elevation = Sediment Thickness**
- **Sediment Thickness – Bedrock Buffer (10-feet) = Available Dredge Depth**
- **Total Dredged Volume = Available Dredge Depth x (length and width of cell) *using 1:3 slope***
- **Total Storage Capacity = Total Volume Dredge – (top 4-foot contaminated material + 4-foot suitable material cap + 3-foot maintenance dredge contingency)**

Table Assumptions:

- All volumes are calculated as Volume of the Void (VOV) and do not take into account sediment properties (i.e., bulking, etc.). The volumes are approximate, and are based on average elevations within each proposed cell.
- **Average Bedrock Elevations** were calculated using Oasis Montaj V5.16 minimum curvature model of the bedrock surfaces within each of the proposed CAD cells. A mathematical modeling cell size of 12 was maintained to construct the minimum curvature model of the bedrock surface.
- **Average Bathymetric Elevations** were calculated similarly to the Average Bedrock Elevations using the USACE bathymetric data 1997 and a mathematical cell size of 8.
- **Sediment Thickness** was calculated by subtracting Bathymetric/Mud line Elevation from the Bedrock Elevation.
- **Available Dredge Depth** is the depth of material excavated allowing the proposed CAD cell to terminate allowing a 10-foot sediment buffer between the bottom of the CAD cell and the bedrock surface. The available dredge depth can also be thought of as the depth of material to the bottom of the proposed CAD cell.
- **Total Volume Dredged** is the amount of material needed to be removed to form the proposed CAD cell given the average dredge depth and assuming a 1:3 (V: H) side slope for each cell.
- **Total Storage Capacity** is the final volume after disposing of the top 4-feet of "contaminated" material back into the cell and allowing for the 4-feet of clean cap material. A maintenance dredge contingency of 3-feet is also allowed for.

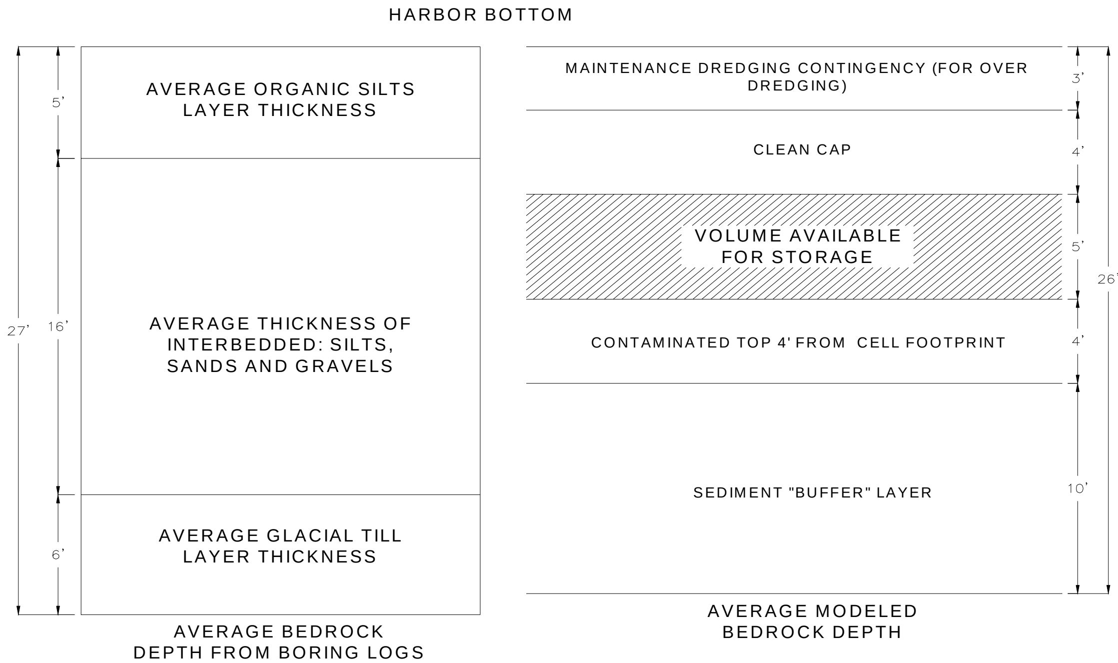


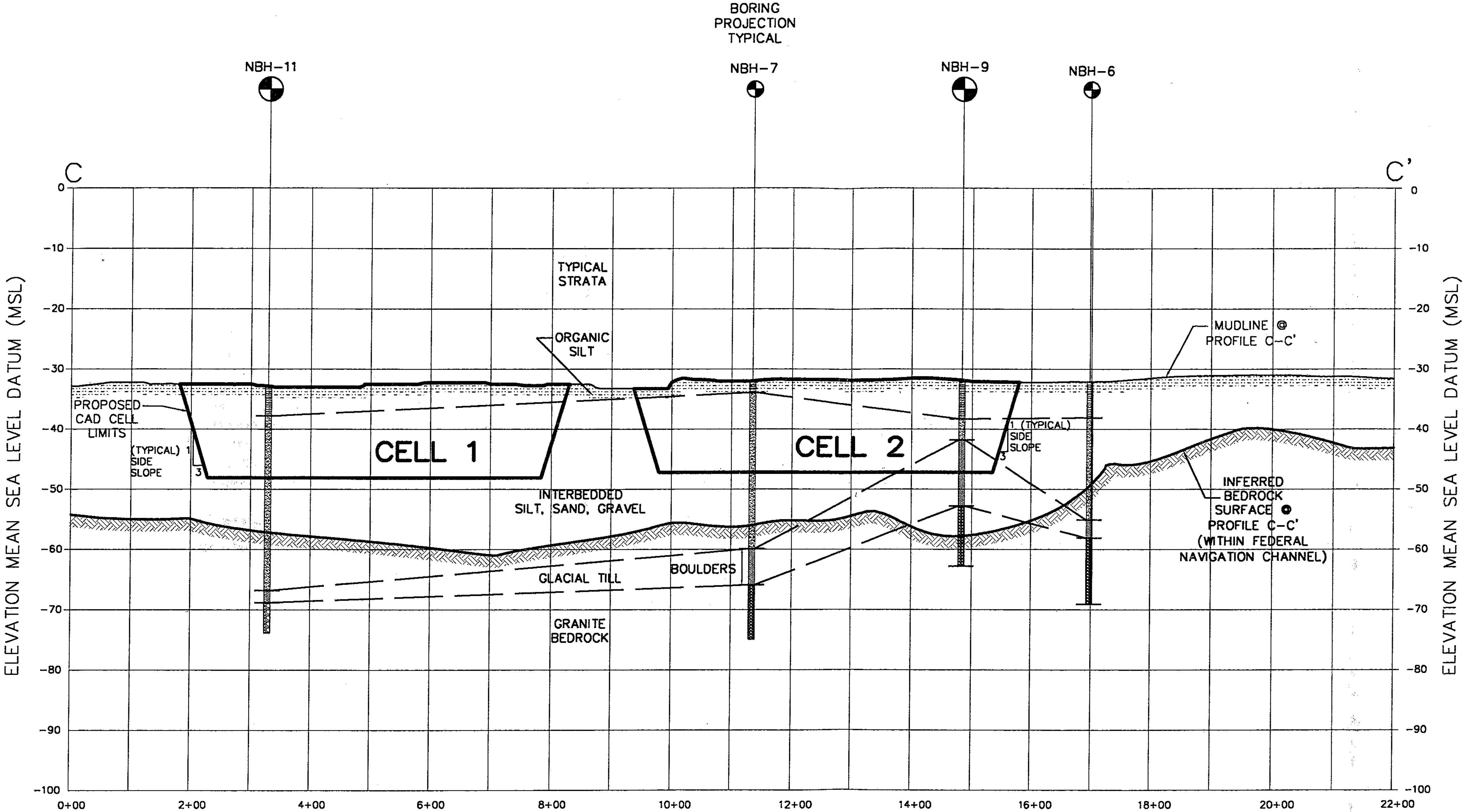
Figure 3-7. Breakdown of the division of available storage capacity and average geological cross section as seen in the borings conducted in the CI area.

3.3.1.2 Cross Section Profiles – Channel Inner Area CAD Cells

Two Stratigraphic Cross Sections were extracted from a profile cut through the CI area proposed CAD cells 1 and 2 (C-C^1) (Figure 3-8) and proposed CAD cell 3 (D-D^1) (Figure 3-9). The cross-sections were constructed by digitizing the modeled bedrock surface and the bathymetric surface over the length of the profile. Boring information collected as part of the project was also extrapolated to the profile centerline to depict the types and thickness of geology encountered.

3.3.1.3 Popes Island Area CAD Cells Volumes Calculations

Volumes were calculated using a conceptual configuration of six cells in the PIN area (See Figure 3-3). Cell 1 was designed for a capacity of 1.8 million cubic yards. Cells 2 through 6 were designed to accommodate approximately 50,000 cubic yards of material each. There is an additional loss of cell volume since the upper four (4) feet of footprint sediment in the PIN area is unsuitable and will be placed back into the cell, taking up volume associated with the top four (4) feet of material. Additionally, a cap of four (4) feet of suitable material will be placed on top, for a cell total of eight (8) feet of depth subtracted from the calculations for each cell. Table 3-3 below summarizes the calculations for the PIN area. For each CAD cell, total storage capacity equals the volume of suitable material expected to be placed, at the proposed BBDS. Figure 3-10 shows a graphical breakdown of the division of available volume and geological types.



LEGEND:

NBH-6 PHASE I PROJECT BORING LOCATIONS

NBH-11 PHASE II PROJECT BORING LOCATIONS

PROFILE STATIONING IN FEET

CHANNEL INNER SUBSURFACE PROFILE C-C'

NOTES:

1. FOR PROFILE ORIENTATION REFER TO FIGURE 5.
2. INFERRED STRATA LIMITS
   FROM BORING INFORMATION.
3. SCALE: HORIZONTAL

0 200 400 600

SCALE: 1"=200' FEET

VERTICAL

0 20 40 60

SCALE: 1"=20' FEET

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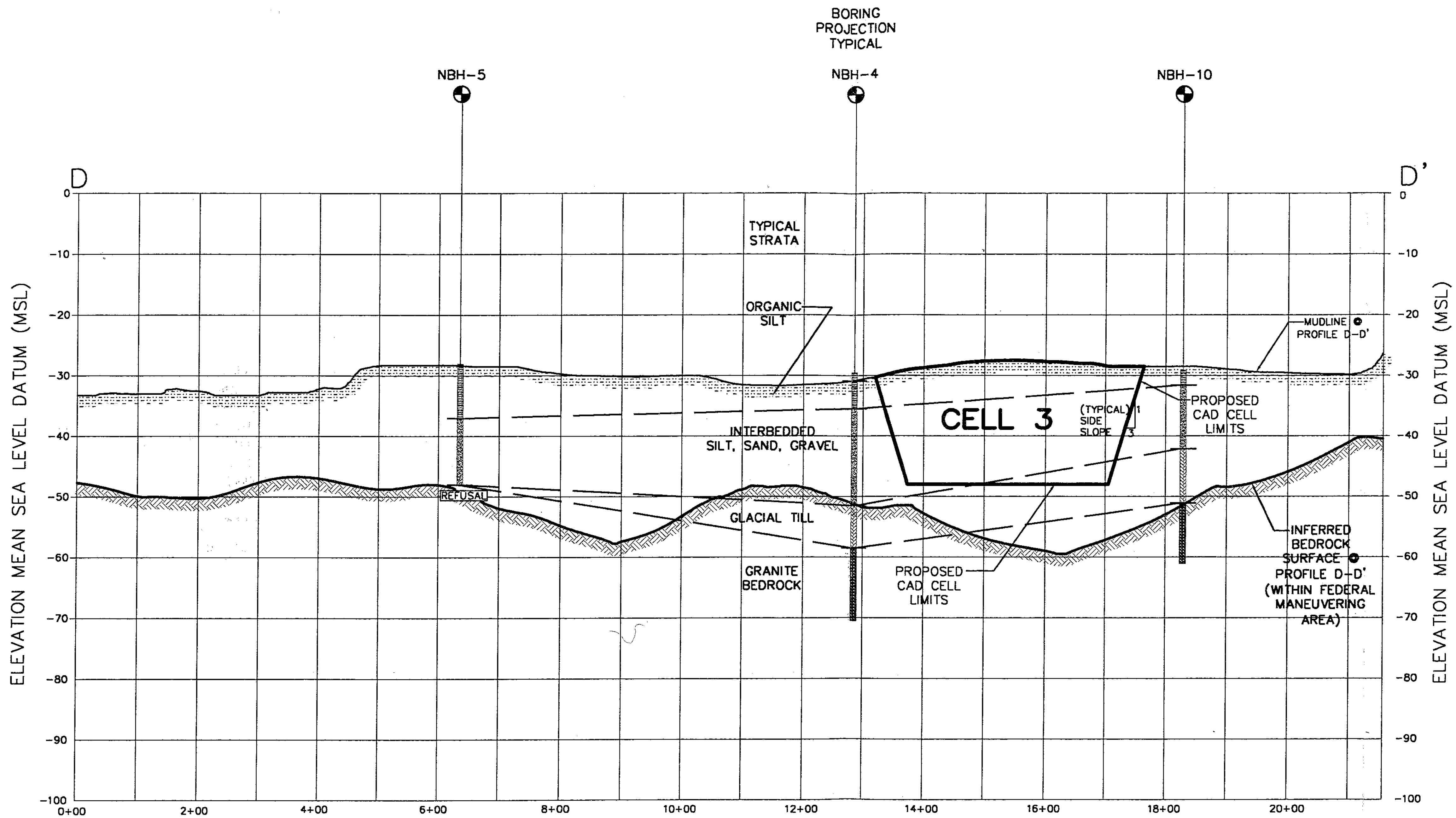
FIGURE 3-8. CHANNEL INNER SUBSURFACE PROFILE C-C'

PROJECT NO.: 16454	
DESIGNED BY: ---	
DRAWN BY: ---	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	



PROFILE STATIONING IN FEET

CHANNEL INNER SUBSURFACE PROFILE D-D'

NOTES:

1. FOR PROFILE ORIENTATION REFER TO FIGURE 5.
2. INFERRED STRATA LIMITS — — — FROM BORING INFORMATION
3. SCALE:

HORIZONTAL

0 200 400 600

SCALE: 1"= 200' FEET

VERTICAL

0 20 40 60

SCALE: 1"=20' FEET

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FIGURE 3-9. CHANNEL INNER SUBSURFACE PROFILE D-D'

PROJECT NO.: 16454
DESIGNED BY: ---
DRAWN BY: ---
CHK'D BY:
DATE: 06/02/03
SCALE: AS NOTED

Table 3-3. Volume Calculation Summary for the PIN area CAD configuration shown in Figure 3-10.

Cell	Average Bedrock Elevation	Average Bathymetric Elevation	Sediment Thickness	Available Dredge Depth	Total Dredged Volume	Total Storage Capacity
1	-75 ft	-8 ft	**67 ft**	57 ft	**2,275,000 CY**	**1,841,000 CY**
2	-50 ft	-6 ft	**44 ft**	34 ft	**82,375 CY**	**48,100 CY**
3	-54 ft	-8 ft	**46 ft**	36 ft	**83,800 CY**	**49,500 CY**
4	-57 ft	-9 ft	**48 ft**	38 ft	**84,950 CY**	**50,700 CY**
5	-58 ft	-9 ft	**47 ft**	39 ft	**65,450 CY**	**51,200 CY**
6	-57 ft	-8 ft	**49 ft**	39 ft	**85,450 CY**	**51,200 CY**

- **Average Bedrock Elevation –Average Bathymetric Elevation = Sediment Thickness**
- **Sediment Thickness – Bedrock Buffer (10-feet) = Available Dredge Depth**
- **Total Dredged Volume = Available Dredge Depth x (length and width of cell), *using 1:3 slope***
- **Total Storage Capacity = Total Volume Dredge – (top 4-foot contaminated material + 4-foot suitable material cap)**

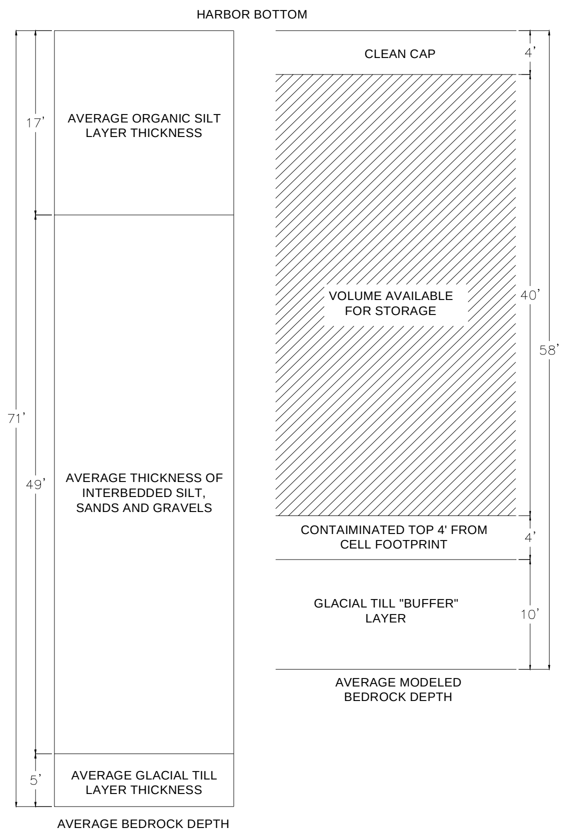


Figure 3-10. Breakdown of the division of available storage capacity and an average geological cross section from the borings conducted in the PIN area.

3.3.1.4 Cross Section Profiles –Popes Island North CAD Cell Area

Stratigraphic cross sections were extracted from profile cuts through proposed CAD Cells 2 – 6 (A-A¹)(Figure 3-11) and CAD Cell 1 (B-B¹) (Figure 3-12) in the PIN area. The locations of the cross sections are shown on Figure 3-3. The cross sections were constructed by digitizing the modeled bedrock surface and the bathymetric surface over the length of the profile. Boring information collected as part of the project was extrapolated to the profile centerline to depict the types and thickness of geology encountered.

3.3.2 Summary

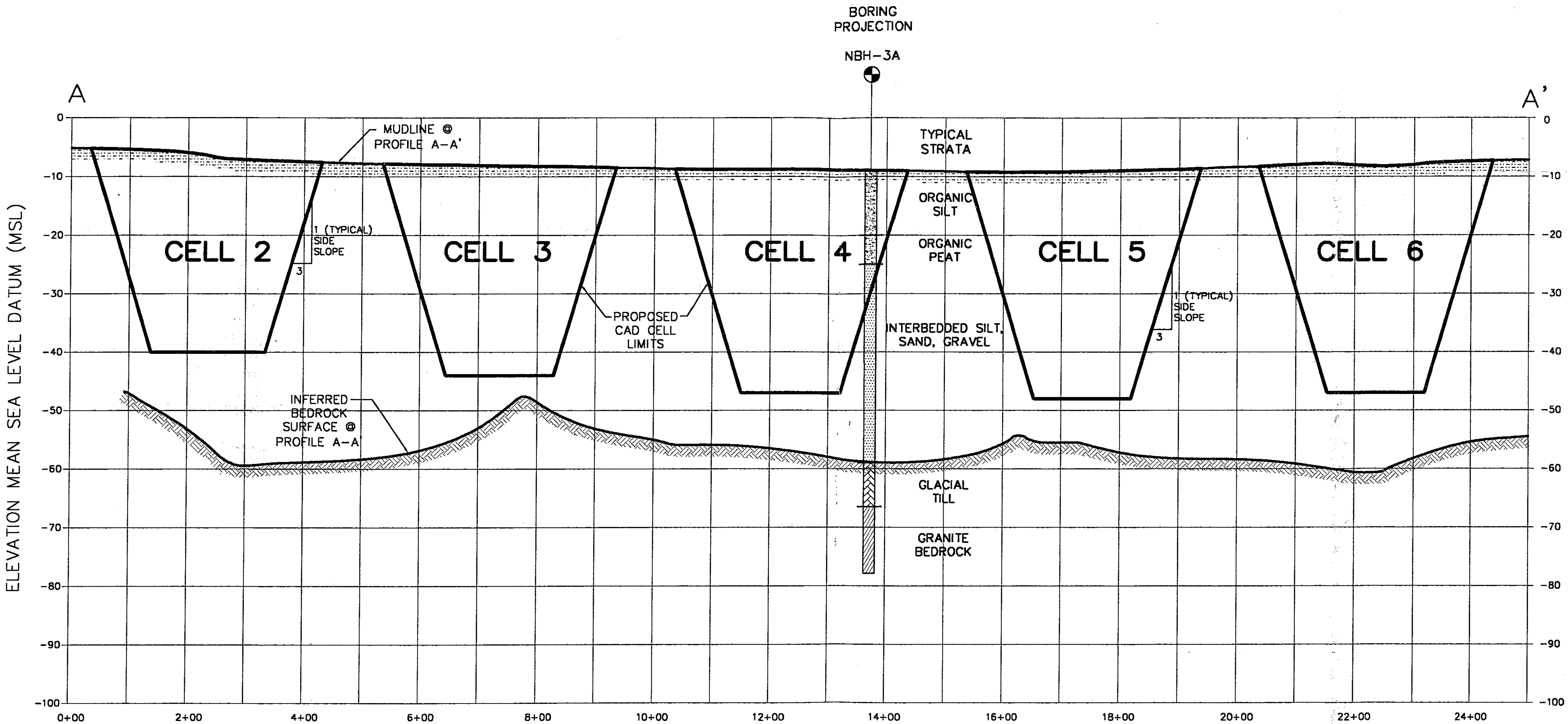
3.3.2.1 Channel Inner

The CI site is an area of uniformly shallow sediment depth, making even a moderate volume project CAD cell expansive in plan-area and relatively inefficient to complete. The inefficiency is due to the limited five-foot depth for contaminated dredge project material after taking into consideration all of the following design parameters; ten-foot bedrock buffer, four-foot suitable cap, additional three-foot operational and maintenance contingency (for protection against over-dredging) and four-foot contaminated CAD cell footprint layer. Therefore, to accommodate considerable dredged material volumes the CI CAD cell footprints must cover a large area. The ongoing and likely increased presence of navigation, maneuvering and anchorage activities overlying the CI site further complicate this area’s development.

3.3.2.2 Pope's Island North

The PIN CAD cell area is a submerged marine geological resource measuring approximately 80 acres by 60 feet deep of sub-aqueous sediment appropriate to sequester approximately 2,050,000 cy of Harbor UDM. The NBHDC has identified an annualized seasonal need to dredge and sequester approximately 50,000 cy of UDM in keeping with Intermediate Goals of their Harbor plan. The DEIR showed long-term Harbor UDM disposal needs at 960,000 cy for ten-years and 2,555, 280 (including 20% contingency) for twenty years. The final CAD cell configuration may vary in layout from the six cell preliminary configuration provided in the FEIR. However, preliminary engineering necessary to characterize the CAD areas required for the State designation required conceptual engineering design of CAD cells. The PIN CAD cell configuration consists of five moderate volume cells approximately 50,000 cy each and one high capacity cell of approximately 1,800,000 cy capacity. This configuration was selected to accommodate several smaller projects and either one major project (such as a USACE maintenance project) or several additional smaller projects. The PIN CAD resource will be designated as a CAD area to be developed to respond to the Harbor’s current and future dredging needs in an the most environmentally responsible and cost-efficient manner.

However the CADs are ultimately configured, it is important to note that the conceptual layout of the CAD area has been designed in response to the revealed subsurface conditions. The relatively shallow sediment depths along the area’s eastern extent, near Marsh Island, favor the moderate



PROFILE STATIONING IN FEET

POPES ISLAND NORTH SUBSURFACE PROFILE A-A'

NOTES:

1. FOR PROFILE ORIENTATION REFER TO FIGURE 2.
2. SCALE:

HORIZONTAL

0 200 400 600

SCALE: 1"=200' FEET

VERTICAL

0 20 40 60

SCALE: 1"=20' FEET

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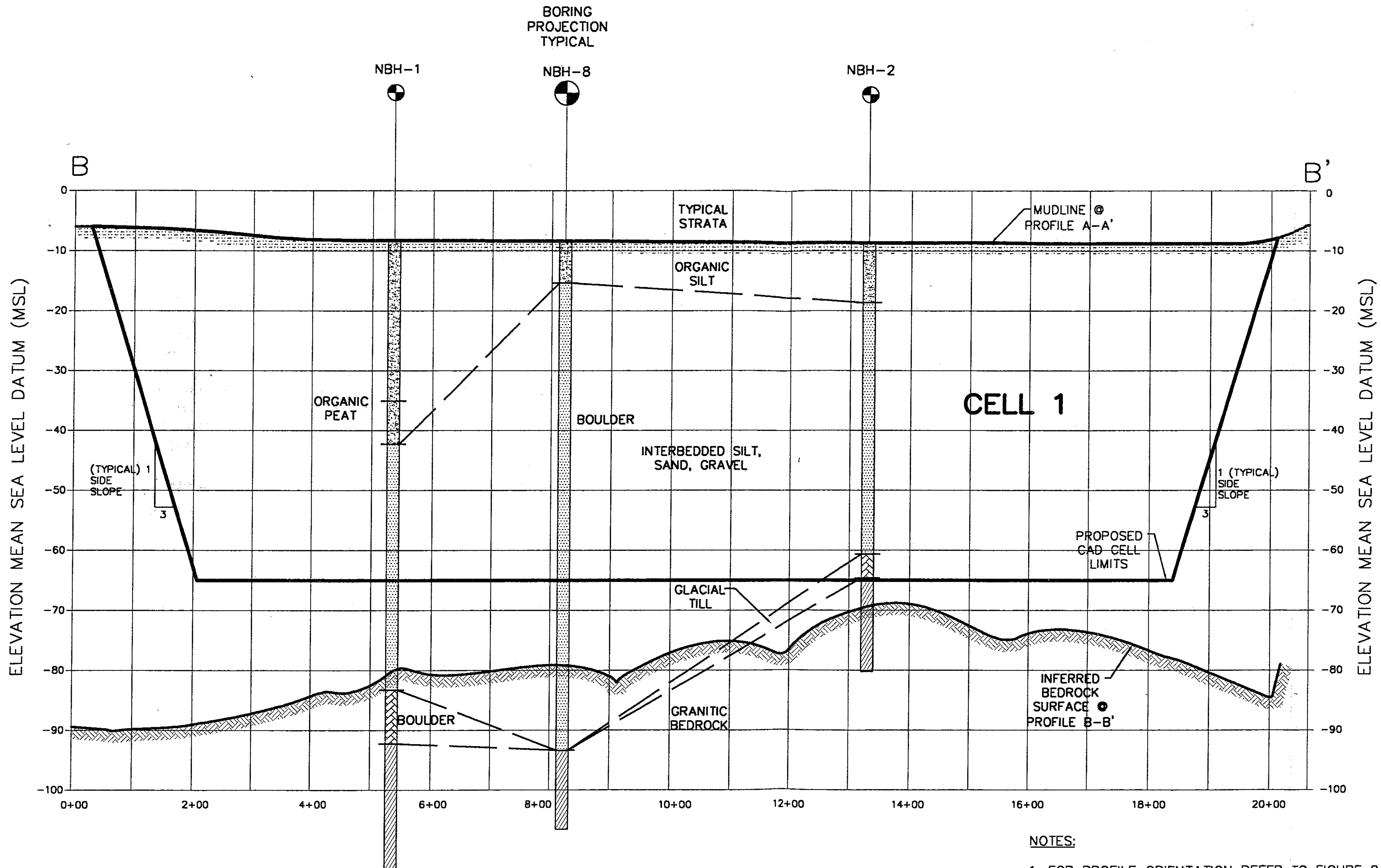
FIGURE 3-11. POPES ISLAND NORTH SUBSURFACE PROFILE A-A'

PROJECT NO.: 16454
DESIGNED BY: ---
DRAWN BY: ---
CHK'D BY:
DATE: 06/02/03
SCALE: AS NOTED

Drawing file: N:\PROJECTS\CIVIL\GEOTECH\APEX ENGINEERING 5-8-03\Presentation Drawings\HALF-SIZES 8-27-03\16451GFC200.dwg Plotted: Sep 15,2003-9:34am By: Wlsovey



PROFILE STATIONING IN FEET

LEGEND:

NBH-1 PHASE I PROJECT BORING LOCATIONS

NBH-8 PHASE II PROJECT BORING LOCATIONS

POPES ISLAND NORTH SUBSURFACE PROFILE B-B'

NOTES:

1. FOR PROFILE ORIENTATION REFER TO FIGURE 2.
2. INFERRED STRATA LIMITS FROM BORING INFORMATION
3. SCALE: HORIZONTAL

0 200 400 600

SCALE: 1"=200' FEET

VERTICAL

0 20 40 60

SCALE: 1"=20' FEET

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FIGURE 3-12. POPES ISLAND NORTH SUBSURFACE PROFILE B-B'

PROJECT NO.: 16454	
DESIGNED BY: ---	
DRAWN BY: ---	
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	

approach. The deeper sediment depths along the western bedrock valley adjacent to Popes Island favor a high capacity CAD cell project approach.

The preliminary CAD cell engineering design configured the five moderate capacity cells in the eastern extent to retain the deeper sediment depths above the western bedrock valley for high capacity project(s). This configuration maximizes of the available area. If necessary, moderate capacity cells may be constructible in the deep sediment over the western bedrock valley. The deep organic layer will be more easily dredged and access from the navigable channel north of Popes Island is convenient. However, if moderate capacity CAD cells are located in the deeper sediment, capacity potential beneath moderate capacity cells will be sacrificed and overall cell capacity will be compromised.

Two approaches may be followed to access the shallower sediment depth eastern extent of PIN CAD cell area. One solution is a course over existing depths of approximately 10 to 12 feet at high tide with low capacity scows of approximately 500 cy. With this approach any additional UDM required to be dredged, for improved scow passage will be added to cell capacity. Another solution is a course over an in-channel CAD cell(s) constructed to 20 feet of draft at high tide with up to a 2000 cy scow load from navigable depths to the eastern area. In the event a high capacity CAD cell was constructed prior to moderate capacity cells in the eastern area, a 20-foot deep channel from navigable waters could be incorporated into the final design. In the latter approaches additional draft to 20 feet above the final cell cap equates to an additional volume of suitable material from the CAD cell(s) disposed of at BBDS, (Note that there may be additional ways to maximize access and efficiency; see the next paragraph.) Generally, rate of UDM disposal is measurable relative to the scow capacity. Cell construction guidelines are included in the PIN CAD cell management plan, Section 8.0.

In conversations with the dredging industry, dredgers have stated that their strong preference is to be allowed to propose construction alternative regarding access routes, capacity, cell design, and location in response to a given volume to be dredged and in configuration of potential future CAD locations (GLDD, personal communication, 2003). The potential impediments described above are presented to generally inform the reader that 1) CAD design and layout will need to be addressed thoughtfully; 2) each design scenario will contain efficiencies and inefficiencies; and 3) dredging management and construction expertise must be employed in final CAD design and management.

3.4 Underwater Archaeological Surveys

An initial literature based assessment of cultural resources, including the location of possible shipwrecks was conducted for the DEIR. The MEPA Certificate included the requirement for site-specific underwater archaeological surveys. For this FEIR, more detailed cultural screening and site-specific marine geophysical surveys were conducted at the Harbor to identify possible cultural anomalies and hazards to the development of CAD cell at either the CI or PIN sites (Apex, 2003, and Appendix B).

3.4.l Goal

The purposes of the survey are to: 1) determine the presence or absence of submerged cultural resources potentially eligible for the National Register of Historic Places; and 2) identify possible hazards to future dredging or disposal activities.

3.4.2 Description of Study

This additional cultural resource assessment presents an analysis of the collected cultural and geophysical data of potentially significant cultural and natural features lying on the harbor bottom that could pose an obstacle or a hazard to dredging. The cultural screening provides an historical context, while the hazards/obstruction screening reflects the results of the underwater surveys completed for this FEIR.

3.4.2.1 Cultural Screening

The first permanent European settlement in the study area began in 1652 when settlers from Plymouth bought the land presently encompassing Dartmouth, New Bedford, Fairhaven and Westport. New Bedford's spacious and naturally deep harbor became an ideal location for the development of the fisheries industry. Whaling soon became the primary industry in New Bedford and Fairhaven. The first whalers in the colonies left from Nantucket and New Bedford as early as 1690. Related maritime industries sprung up in New Bedford, and particularly Fairhaven, in support of the whaling industry, including shipbuilding, ropewalks, and candle factories. Water depth in the harbor was reported between 18 and 24 feet (Ricketson, 1858). However, by 1888, whaling had declined dramatically. Only 74 whalers worked out of New Bedford in that year, with a tonnage of 18,911 (Sayer, 1889). Ultimately, the future of whaling as a source of oil was ended once Colonel Drake discovered oil in the ground in northwestern Pennsylvania in 1859. By the end of the nineteenth century, whaling had given way to textile mills as the leading industry in the New Bedford economy. It was not until after the First World War, when the introduction of diesel powered fishing boats allowed vessels to economically reach the rich offshore fishing banks, that New Bedford once again became a prominent fishing port.

Massachusetts Bureau of Underwater Archaeology (MBUA) files contained information on three previous archeological surveys in the project vicinity including the DEIR (Maguire, 2002) (Cox, 2001) (Cembrola, 1989). For two of these projects conducted previously in the Harbor a number of targets identified by magnetic and acoustic surveys as possible archaeological importance turned out to be modern debris and derelict vessels that did not satisfy Two of the projects were completed using. The report concluded that none of the vessels satisfied National Register of Historic Places (NRHP) criteria (Cox, 2001a).

3.4.2.2 Hazards/Obstructions Screening

Marine geophysical data for this survey was collected from the two areas of the Harbor that are of interest to the project: CI and PIN. The geophysical was comprised of site-specific geophysical surveys that covered CI and PIN CAD study areas using two survey techniques:

side scan sonar and magnetometer. The data were processed and interpreted by geophysicists, and potential targets, which may represent cultural resources and/or hazards to the future operations, were identified and registered on summary maps of the areas. These target summary maps display the locations of the potential targets identified on a base map of New Bedford Harbor (Appendix F).

Field operations for the Harbor marine geophysical survey were conducted from October 21 through October 24, 2002. The marine surveys were conducted from a 32-foot aluminum survey vessel, *R/V Cyprinodon,* outfitted with side scan sonar and a magnetometer. Shipboard systems were integrated with a Differential Global Positioning System (DGPS) so that the geophysical data collected from the instruments could be tagged with precise position information at regular intervals.

3.4.3 Results

Preliminary analysis and interpretation of the geophysical survey information was performed each day in order to plan the remaining work or modify the survey program in specific areas. The objective of the data analysis and interpretation phase was to characterize the responses from the geophysical data in terms of their most probable sources (i.e., rock, buried object, pipe, cable, etc.). An integrated approach to the analysis and interpretation phase was implemented for this project, in which targets and features detected by magnetic and side scan sonar imagery were collectively interpreted. This strategy allowed targets and features detected by both instruments to be more accurately characterized in terms of depth and probable source. The magnetic and side scan data were also analyzed and interpreted in concert with the historic structure pattern and lithologic and geotechnical sampling data existent for the harbor. Experienced geophysicists identified target and feature responses within the data and generated color-coded maps and target anomaly lists for the geophysical anomalies.

3.4.4 Summary

Numerous targets of interest were identified on the summary maps. These targets included both potentially manmade and natural objects and features. The “cultural” objects identified include: linear features which are thought to be indicative of the presence of pipes and cables; individual targets thought to generally represent stand-alone features such as mooring blocks, anchors, and miscellaneous dropped objects; and groups of targets clustered together and thought to generally represent modern vessel debris. Analysis of remote sensing data identified 43 magnetic and/or acoustic targets in the two survey areas. Most of the targets appear to be isolated single source objects, modern debris, or geologically related objects. While three of the remote sensing targets found in the CI survey area generated magnetic signatures suggestive of submerged cultural resources, they are located within the dredged portion of the federal channel. This indicates that the target sources are very likely modern debris since such areas were subjected to periodic maintenance dredging.

None of the remote sensing targets appears to contain submerged cultural resources. No additional underwater archeological investigation is recommended. Several of the targets identified (such as large sections of old dock), may represent difficult issues for future dredging or other project operations, and may require further investigation.

3.5 Physical And Chemical Analysis Of Surficial Sediments

Physical and chemical analyses of surficial sediments in the CAD cell areas were determined for this FEIR (Maguire, 2003, and see Appendix E, F; ENSR, 2003). Additionally, marine water samples were collected to support elutriate testing for use in site-specific water quality assessment study.

3.5.1 Goal

Goals of the site-specific surficial sediments sampling and analyses to determine the vertical and horizontal horizons of surficial unsuitable dredged materials (UDM) and analyze sediment of the benthos in the preferred alternative CAD cell sites. Site-specific surficial sediment sampling was conducted for physical analysis through two sampling techniques 1) vibracore probes for surficial chemistry analysis; and 2) surface grab sampling as part of the sediment grain size for the macrobenthic analysis study (Maguire, 2003; ENSR, 2003).

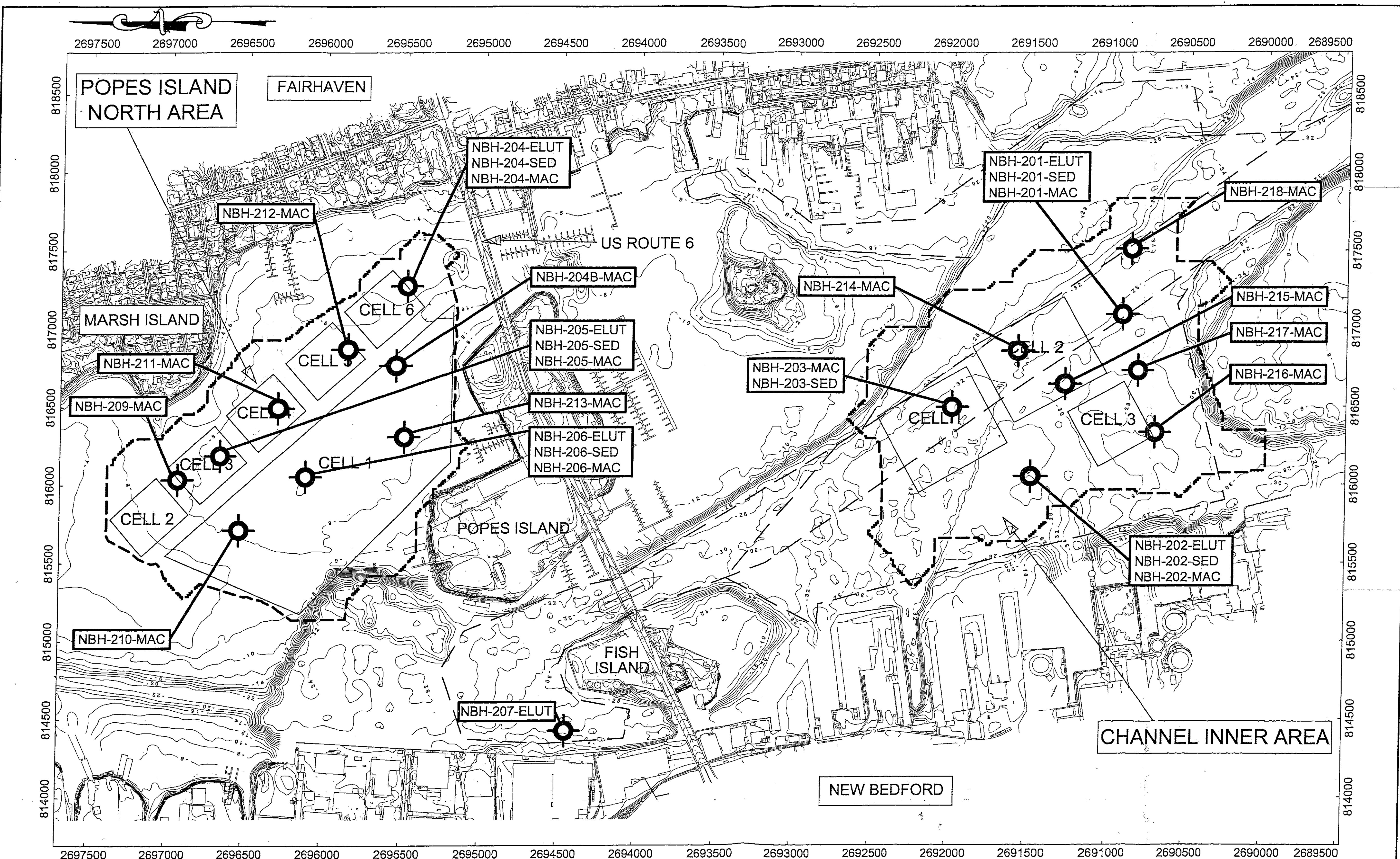
One set of surficial sediment data were collected in the CAD sites for chemistry at intervals using metals as indicator parameters to screen for a subsequent comprehensive suite of laboratory analyses (Maguire, 2003). Comprehensive laboratory analyses for PAHs, pesticides, dioxins, and PCBs were then performed to identify the extent of chemical contamination. This sampling plan was discussed and confirmed with the USACE New England Regulatory Division as practicable and sufficient for the purpose of State CAD Site designation (USACE, September 2002). In this discussion with the USACE, the collective assumption was that a deposition rate of approximately one centimeter per year over the last 150 years would limit the vertical extent of contamination to less than four feet. This assumption was based on the USACE contribution to the discussion that the annual sediment deposition rate of 1cm/yr over the past 150 years since the dawn of the industrial age in New England was typical (USACE, September 2002). This assumption was to be confirmed by the results of the sampling plan.

3.5.2 Description of Studies

3.5.2.1 Chemical

Twelve vibracore sediment sample probes were advanced in the preferred alternative CAD sites from the RV Cyprinodon, a 32-foot aluminum research vessel, on October 10, 2002, with oversight by Maguire personnel (Figure 3-13). Vibracore sample locations were selected on the basis of the following criteria; investigation history, access, adequate subsurface coverage within the CAD cell areas, and utility line locations. Vibracore borings were advanced to depths up to 12 feet below grade utilizing a suspended pneumatic vibratory hammer. The locations of vibracore borings are depicted in Figure 3-14.

Selected sediment samples were placed in clean glass jars for preliminary analysis of metals at a USACE-certified laboratory. On October 11, 2002, the following sediment samples were



NOTES:

1. Base Plan of the New Bedford Harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).

SURFICIAL SEDIMENT SAMPLING LOCATIONS AT CHANNEL INNER AND POPES ISLAND NORTH CAD CELL SITE ARES

0 600 1200 1800

SCALE: 1"=600' FEET

LEGEND & ABBREVIATIONS

SAMPLING LOCATION

W-ELUT = ELUTRIATE
WATER = SURFACE WATER

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FIGURE 3-14. SURFICIAL SEDIMENTARY SAMPLING LOCATIONS AT CHANNEL INNER AND POPES ISLAND NORTH CAD CELL SITE AREAS

PROJECT NO.: 16454
DESIGNED BY: ---
DRAWN BY: ---
CHK'D BY:
DATE: 06/02/03
SCALE: AS NOTED

submitted for metals analysis at AMRO Environmental Laboratories Corporation, located in Merrimack, NH.

3.5.2.2 Grain Size and TOC

The sediment grain-size and TOC samples were taken in CI and PIN from the same research vessel as the vibracores on a later date, October 30, 2002. One grab sample dedicated to grain size analysis and TOC was collected at each of seventeen stations; eight at CI and nine at PIN. Sediment grain-size samples were removed using a 2.5-cm diameter sub-corer and the sample placed in a WhirlPac®. Sediment for TOC was also removed from this sample with a stainless steel spoon and placed in a 125-ml glass jar. All sediment grain-size and TOC samples were stored on ice through the duration of the survey and for shipping. The locations of sediment grain size and TOC samples are depicted in Figure 3-14.

Figure 3-13. Maguire staff collecting marine surficial sediment samples.

3.5.3 Results

3.5.3.1 Chemical

Test vibracore borings indicated marine deposits of dark organic silt underlain by inorganic silt and clay. The dark organic silt included shell hash and other harbor bottom detritus. The inorganic silt and clay was observed to contain mostly silt, fine sand, and clay as well as trace gravel, coarse and medium sand. The hue of the underlying silt/clay strata was various shades of gray. Completed Vibracore Boring Reports are included in Appendix D. Bedrock and significant evidence of boulders were not encountered during the surficial sediment investigation activities. The preliminary laboratory results were obtained on an accelerated schedule to facilitate the submittal of sediment samples for more detailed analysis (Table 3-4).

Table 3-4. Preliminary Sediment Analytical Results (PPM)

Sample Location	Cell	Depth	As	Ba	Cd	Cr	Cu	Pb	Ni	Se	Ag	Zn	Hg
NBH-201-1-SED	CI	0-1.5'	**35**	67	3.9	*280*	**560**	*180*	33	<1.4	4.5	*390*	*1*
NBH-201-2-SED	CI	1.5-3.3'	**37**	70	*5.7*	*270*	**670**	**240**	30	<1.4	2	**450**	**1.7**
NBH-201-3-SED	CI	3.3-5'	9.2	37	0.92	1.8	170	4.6	7.4	<0.92	2.6	3.7	0.077
NBH-202-1-SED	CI	0-2'	**35**	67	3.9	*280*	**560**	*180*	33	<1.4	4.5	*390*	*1*
NBH-202-2-SED	CI	2-4'	**37**	70	*5.7*	*270*	**670**	**240**	30	<1.4	2	**450**	**1.7**
NBH-202-3-SED	CI	4-6.25'	9.2	37	0.92	1.8	170	4.6	7.4	<0.92	2.6	3.7	0.077
NBH-203-1-SED	CI	0-1.7'	**29**	50	3.5	*260*	**460**	**200**	27	1.8	5.7	*360*	*0.9*
NBH-203-2-SED	CI	1.7-3.4'	**22**	29	<0.97	36	150	84	12	1	0.65	140	*0.6*
NBH-203-3-SED	CI	3.4-5'	4.8	2.3	<0.68	4.3	11	6.3	1.7	0.48	<0.19	13	0.058
NBH-204-1-SED	PIN	0-1.5'	6.7	4.3	<0.77	19	50	24	3	0.55	<2.1	33	0.17
NBH-204-2-SED	PIN	1.5-2.2'	6	2.7	<0.7	4.5	4.7	3.9	2.4	<0.7	<2	8.4	<0.056
NBH-204-3-SED	PIN	2.2-4.6'	*11*	2.6	<0.73	8.7	5.6	4	8	2.1	<2	20	<0.061

Table 3-4. Preliminary Sediment Analytical Results (PPM)

Sample Location	Cell	Depth	As	Ba	Cd	Cr	Cu	Pb	Ni	Se	Ag	Zn	Hg
NBH-205-1-SED	PIN	0-2'	**28**	49	<1.2	52	*290*	*140*	18	0.76	0.79	180	*0.62*
NBH-205-2-SED	PIN	2-4'	**25**	16	<1	23	9.7	7.7	12	<1	<2.8	35	<0.083
NBH-205-3-SED	PIN	4-6'	*15*	9.8	<0.91	17	6.4	5.3	9.2	<0.91	<2.5	27	<0.070
NBH-205-4-SED	PIN	6-8'	*17*	9.4	<0.88	16	6.2	4.8	8.8	<0.88	<2.5	32	<0.069
NBH-206-1-SED	PIN	0-2'	**35**	65	0.84	*250*	**610**	**250**	32	1.4	2.3	*290*	**2**
NBH-206-2-SED	PIN	2-4'	**25**	18	<1.1	27	19	17	14	0.64	<3.1	47	0.043
NBH-206-3-SED	PIN	4-6'	**29**	17	<1.1	28	9	8.1	15	0.52	<3.2	43	<0.091
NBH-206-4-SED	PIN	6-7'	**28**	15	<1	26	8	7.2	14	0.69	<2.8	39	<0.083
Category One			<10		<5	<100	<200	<100	<50			<200	<0.5
Category Two			*10-20*		*5-10*	*100-300*	*200-400*	*100-200*	*50-100*			*200-400*	*0.5-1.5*
Category Three			**>20**		**>10**	**>300**	**>400**	**>200**	**>100**			**>400**	**>1.5**

Notes: Categories for Chemical Constituents in Dredge Material as presented in 314 CMR 9.07 presented here for reference purposes only.
Yellow highlighted entries indicate samples submitted to detailed confirmatory analysis.

Selenium was not detected in sediment sample locations NBH-201 and NBH-202 obtained from the CI CAD cell area. Cadmium was not detected in sediment sample locations NBH-204 and NBH-205 obtained from the PIN CAD cell area. Arsenic, barium, cadmium, chromium, copper, lead, nickel, selenium, silver, zinc, and mercury were detected at various concentrations in every other sediment sample. Based on these preliminary results, sediment samples NBH-202-3-SED and NBH-206-3-SED were submitted for detailed confirmatory analysis.

Sediment samples NBH-202-3-SED and NBH 206-4-SED were identified for analysis of organochlorine pesticides, PAHs by EPA Method 8270, PCB Congeners by Method 8082, TOC by Lloyd Kahn Method, total solids, Particle Size by ASTM Method D422, and Moisture Content by ASTM Method D2216 (Table 3-5).

In the detailed confirmatory analysis, dioxins were not detected above laboratory quantification limits for sediment sample NBH-202-3-SED obtained from the CI area. Varieties of PAHs and PCB congeners were identified in NBH-202-3-SED. Endrin and endosulfan II (pesticides) were detected in the sediment sample NBH-202-3-SED at concentrations of 22 µg/kg and 27 µg/kg, respectively. Total solids and total organic carbon were respectively determined to be 63.3% and 158 mg/kg. The physical composition of sediment sample NBH-202-3-SED was determined to be a fine sandy clay silt.

Table 3-5. Confirmatory Sediment Sample Analytical Results

Laboratory Method	**NBH-202-3-SED**	**NBH-206-3-SED**
PAHs by EPA Method 8270	Naphthalene 79 µg/kg Acenaphthylene 100 Acenaphthene 83 Fluorene 80 Phenanthrene 460 Anthracene 180 Fluoranthene 620 Pyrene 940 Benz(a)anthracene 440 Chrysene 430 Benzo(b)fluoranthrene 420 Benzo(k)fluoranthrene 160 Benzo(a)pyrene 400 Indeno(1,2,3-cd)pyrene 240 Benzo(g,h,i)perylene 270	BQL
Organochlorine Pesticides by EPA SW8081A	Endrin 22 µg/kg Endosulfan II 27	BQL
Dioxins	BQL	BQL

Table 3-5. Confirmatory Sediment Sample Analytical Results

Laboratory Method	**NBH-202-3-SED**		**NBH-206-3-SED**	
PCB Congeners	BZ#28	39 μg/kg	BZ#66	4.2 μg/kg
	BZ#49	400		
	BZ#52	710		
	BZ#66	600		
	BZ#81	310		
	BZ#87	310		
	BZ#101	270		
	BZ#105	130		
	BZ#118	250		
	BZ#123	250		
	BZ#128	94		
	BZ#138	320		
	BZ#153	210		
	BZ#156	42		
	BZ#170	34		
	BZ#180	37		
Total Solids	63.3%		52.6%	
Total Organic Carbon	158 mg/kg		191 mg/kg	
Grainsize Analysis	Gravel	1.4%	Gravel	0.0%
	Sand	40.4	Sand	7.8
	Coarse 1.1		Coarse 0.0	
	Medium	7.7	Medium	1.7
	Fine 31.6		Fine 6.1	
	Silt	39.5	Silt	54.4
	Clay	18.7	Clay	37.8

Notes:	Only concentrations detected above laboratory quantification limits are presented. Units are as presented. BQL = Below Laboratory Quantification Limits

Dioxins, PAHs, and pesticides were not detected above laboratory quantification limits for sediment sample NBH-206-3-SED obtained from the PIN area. Only one PCB congener (BZ#6 - Ballschmiter - "BZ Numbers") was detected above laboratory quantification limits. Total solids and total organic carbon were respectively determined to be 52.6% and 191 mg/kg. The physical composition of sediment sample NBH-206-3-SED was determined to be a clay silt. Table 3-6 presents a summary of confirmatory sediment sample analytical results. Original laboratory data, laboratory QA/QC, methods, and the chain-of-custody form are included in Appendix D.

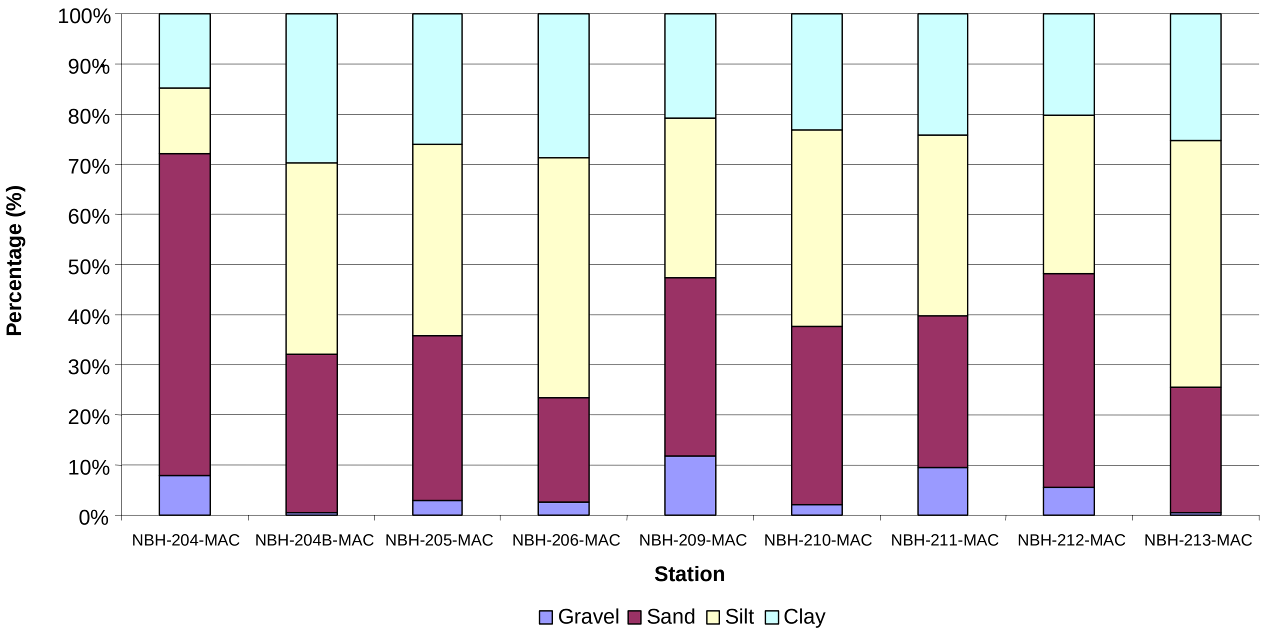


Figure 3-15. Sediment Composition at Channel Inner from grab samples.

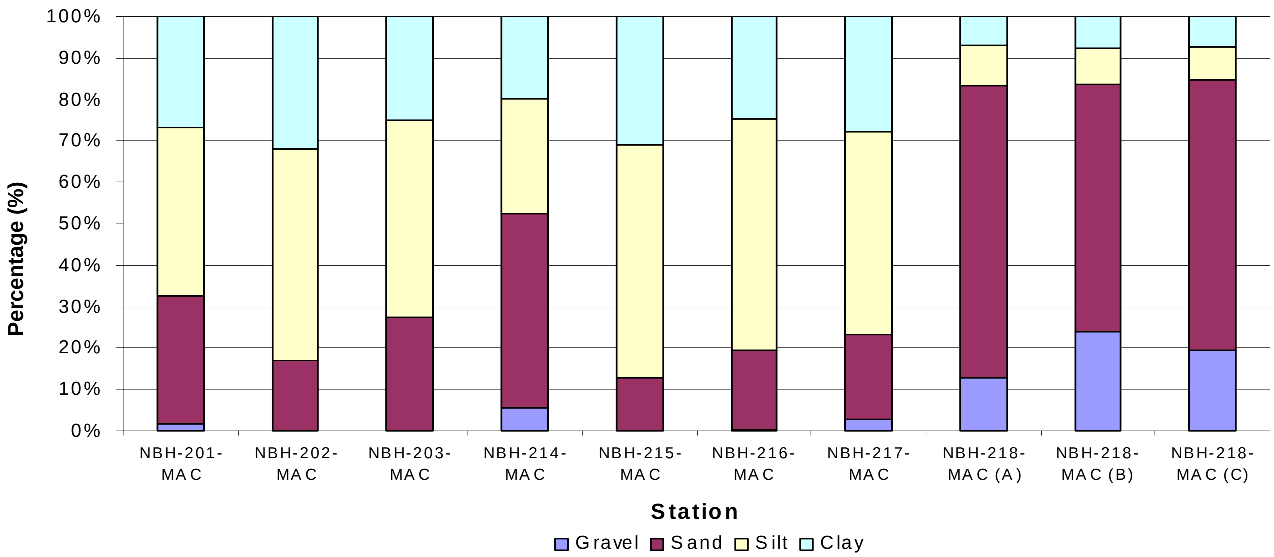


Figure 3-16. Sediment composition at Popes Island North from grab samples

3.5.4 Grain Size and TOC

Sediment grain-size composition was measured for each station sampled. Sediment grain-size composition for eight stations sampled in the CI proposed CAD cell site are found in Figure 3-15. Mean values of percent gravel, sand, silt and clay for nine stations sampled in the proposed PIN CAD cell site are shown in Figure 3-16. Sediments were comprised predominantly of silt and clay except station NBH-204-MAC which had more than 70% gravel and sand. Similar to the Popes Island North CAD cell sites, the composition of the sediment is predominantly silt and clay except at station NBH-218-MAC that was mostly sand (70%) with nearly 20% gravel. Station NBH-214-MAC had approximately 47% sand, 47% silt and clay, and 6% gravel.

The total organic carbon (TOC) found in the sediments collected from the proposed CAD cell sites generally paralleled the trend that sites with greater percentages of silt and clay had higher TOC values. For example, stations NBH-202-MAC from CI and NBH-206-MAC and NBH-210-MAC, located in PIN, had the highest TOC values. These sites also had sediments containing more than 50% silt and clay. Sediments from NBH-204-MAC had the lowest TOC value (mean 2.2% dry wt.) in the Popes Island North samples and the sediment texture for this station was greater than 50% sand (Figure 3-16).

Values for TOC analyzed from Channel Inner sediment ranged from 0.70 to 5.50% dry weight (wt.). Values for TOC analyzed from Popes Island North sediment ranged from 2.04 to 6.44 % dry wt. Average TOC at Popes Island North (4.74% dry wt.) was greater than at Channel Inner (4.02% dry wt.) but not significantly different (t-test 0.99; df=18; $p<0.05$) (ENSR, 2002).

3.5.5 Summary

3.5.5.1 Chemistry

One representative surficial sediment sample from each preferred alternative CAD cell site areas was analyzed in detail for physical and chemical character. From the approximately 90-acre CI CAD cell site area, sample NBH-202-3-SED was analyzed. This NBH-202-3-SED did not show a clear delineation between suitable and unsuitable sediment horizons at the sample location. The CI CAD cell site is in an active harbor area where harbor bottom surficial sediment is very likely disturbed from on-going operations. From approximately 80-acre PIN CAD cell site area sample NBH-206-3-SED was analyzed. The PIN CAD cell site area is not in an area of the harbor where the bottom has been operationally disturbed. The NBH-206-3-SED sample showed a clear delineation between suitable and unsuitable sediment horizons. Vibracore samples were taken at two-foot intervals. The concentrations of the predominant metal, copper, as well as those of other metals diminished by the third interval sampling station. This particular station was tested for the comprehensive laboratory suite of analysis at that third interval. For NBH-206-3-SED, dioxins PAH and pesticides were not detected above laboratory quantification limits in this latter interval sample. For the preferred alternative CAD sites area-wide surficial sediment investigation of this FEIR, a four-foot sediment layer was identified as unsuitable for unconfined aquatic disposal. The specific depth of the unsuitable layer over the extent of the CAD area may be refined based on project-specific testing.

3.5.5.2 Grain Size and TOC

Most of the stations sampled as part of this 2002 survey were comprised of silt and clay with high total organic carbon concentrations. Because contaminants typically bind to finer grain size particles it is likely that these stations have chemical contamination. The marine sediment of New Bedford/Fairhaven Harbor is historically contaminated with PCBs, PAHs, and heavy metals (ENSR 2001). Data for sediment chemistry is presented in the 1999 NBH LTM report (ENSR, 2001). The 1999 monitoring effort showed that PCB concentrations in the proposed CAD cell locations ranged between 1-50 ug/g dry weight. Copper concentrations found in the 1999 study ranged between 100 and >1000 ug/g dry weight. Sediment toxicity from the 1999 study was less than 60% survivability at all Segment 2 sites corresponding to the proposed CAD cell locations. This supports the surficial sediment chemistry findings noted above, that the sediment in the vicinity of the proposed CAD cell sites is anthropogenically affected and contaminated (MAGUIRE, 2003).

3.6 Macrobenthic Sampling and Identification

The Draft EIR proposed and DEIR Certificate concurred that a site-specific benthic macrofaunal assessment to supplement the benthic habitat information presented in the DEIR needed to be conducted for the FEIR. A macrobenthic survey, was conducted at the preferred alternative CAD sites on October 30, 2002 (ENSR, 2003). Benthic organism samples were collected to determine the macrofaunal diversity at both preferred CAD sites. Substrate grain size and TOC samples helpful in the benthic community characterization described in section 3-6 were collected concurrently. This detailed site-specific benthos characterization will serve as a baseline for future benthic community monitoring in the CAD cell areas. In addition, the findings are compared to previous characterization of Buzzards Bay benthic communities to further define the level of environmental degradation in the Harbor.

3.6.1 Goal

The goal of this study was to confirm previous harbor-wide findings presented in the DEIR that the benthic communities of the preferred alternative disposal sites CI and PIN will be impacted by development of CAD in the short-term but that in the long-term the impacted areas will recolonize (Maguire, 2002). This study was primarily expected to determine the macrofaunal diversity in the harbor-bottom surficial sediment. It has been anticipated that there would be close compatibility between Sediment Profile Images (SPI), shown in the DEIR, at the New Bedford/Fairhaven Harbor proposed CAD cell sites and the results from the benthic infaunal analysis of this FEIR (Maguire, 2002). The determined macrofaunal diversity will become the baseline for future benthic community monitoring at the CAD sites during and after CAD closure to ensure UDM is not recontaminating the Harbor environment.

3.6.2 Description of Study

The CAD cell site macrofaunal survey (October 30, 2002) sample collection and data analysis were performed consistent with the same methods employed for the New Bedford Harbor (NBH) long-term monitoring (LTM) effort in 1999 to provide a consistent basis for comparison. This NBH LTM plan was developed by the Environmental Protection Agency's (EPA) Research Laboratory (Atlantic Ecology Division) in an effort to assess the effectiveness of the Superfund remedies. The LTM plan focuses on the ecological health of the sediments and includes collection of data on sediment chemistry, grain size, toxicity, and benthic infauna. The LTM plan methodology was based on a format originally developed as part of the Environmental Monitoring and Assessment Program (EMAP) as implemented for the baseline sampling conducted in 1993 (Nelson et al. 1996). The LTM plan divided the Harbor into three segments of which Segment 2, the lower Harbor, corresponds to the area where the proposed CAD cells will be placed. In 1999, 28 stations, within a hexagonal grid, were sampled in Segment 2. Nine of these sampling stations are in the vicinity of the proposed CAD cell sites. Figure 3-18 shows the hexagons sampled during the 1999 NBH Long Term Monitoring Study (in red) that correlates with the two proposed CAD cell sites.

Seventeen samples were taken from the proposed CAD cell areas. Eight replicated stations were deemed sufficient to represent the benthic macrofaunal communities. Segment 2 sediment samples from the 1999 LTM plan were used to supplement the data collected from the proposed CAD cell sites to provide further cost-effective information about this area. To be consistent with the sampling protocol in the LTM plan, a 0.04 m^2 Ted Young Modified Van Veen Grab was used to collect the benthic samples (Figure 3-18). Navigation was performed using a Hypack Differential Global Positioning System (DGPS). Stations were located using the target coordinates determined previous to the survey.

Each benthic biology grab sample was checked for depth of penetration (7 cm or greater was considered acceptable), depth of the apparent redox potential discontinuity (RPD), presence of surface biology, odor, sediment color, and texture. A rough description of the appearance of the sediment was included in the field notes. Samples were washed into a bucket, sieved through a 500-micron mesh screen, and fixed in 10% buffered formalin. These samples were later re-sieved, rinsed with freshwater, and preserved in 80% ethanol. The sediment grain-size and TOC samples were taken from a third grab, at each station, in order to preserve the integrity of the benthic biology samples. Extraction of TOC and laboratory grain-size analysis was performed. Benthic organism samples were sorted and identified by species under laboratory conditions. Sample processing generally followed protocols described in EMAP Near-Coastal Laboratory Procedures Macrobenthic Community Assessment (EPA, 1991) which was the same protocol used to identify the animals collected during the LTM study.

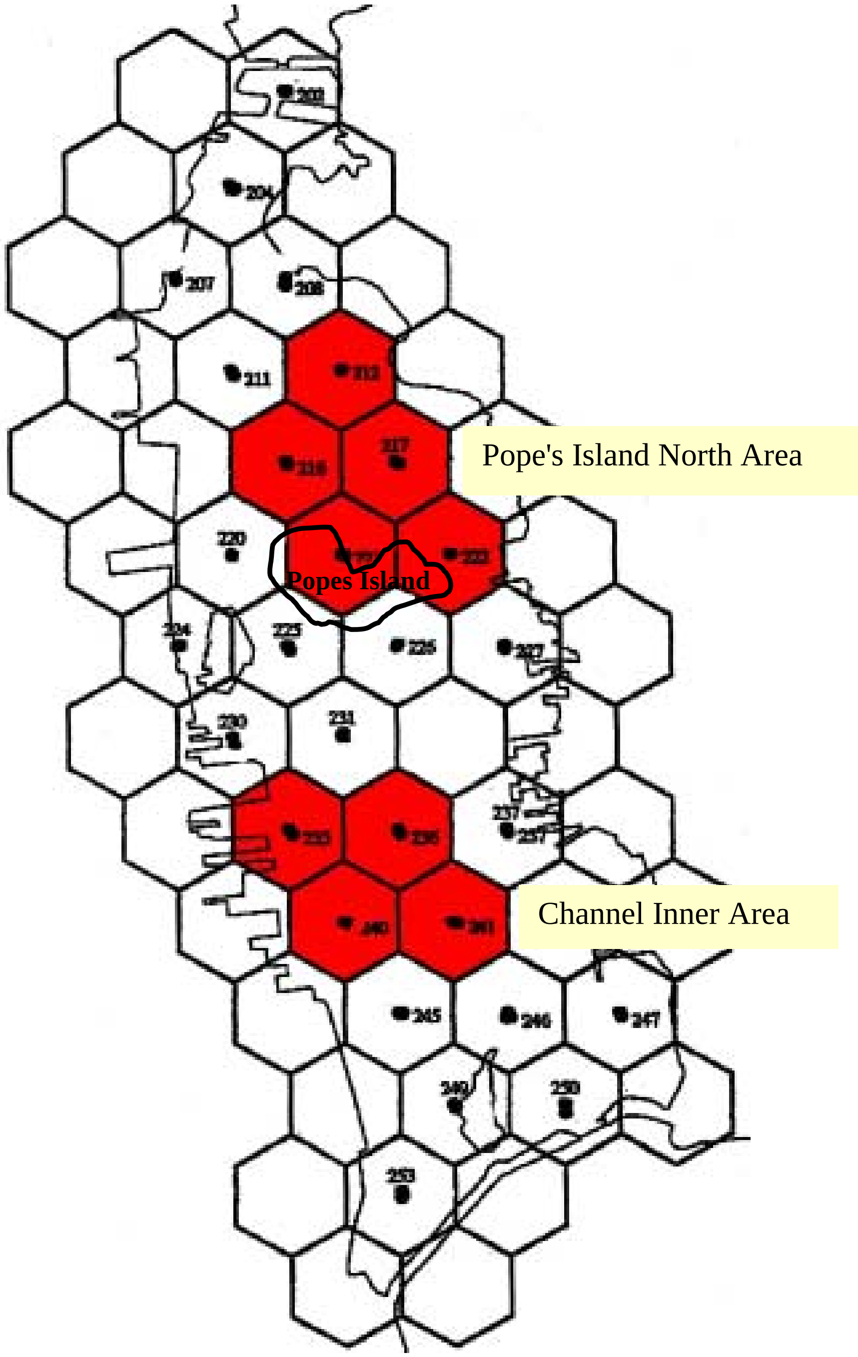


Figure 3-17. Map showing station numbering system for New Bedford Harbor Long Term Benthic Monitoring (USACE), Section 2. Areas highlighted in red are those previously sampled by the USACE in the vicinity of the proposed CAD cell locations.

Figure 3-18. Marine scientist tending the Ted Young Modified Van Veen Grab for this study in New Bedford Harbor.

3.6.3 Results

Each of the stations was analyzed for abundance, density, diversity and evenness. After the samples from the proposed CAD cell sites were completely analyzed the results were compared with the data obtained from Section 2 in the NBH LTM 1999 Harbor study (ENSR, 2001). For the present study, 16 stations were sampled and of these 8 were analyzed for benthic infaunal parameters with the thought that previous data from the Segment Two NBH LTM 1999 study could be used to supplement information and make comparisons to determine if anomalies exist. The Segment Two sampling areas of the Harbor correspond generally to the preferred alternative CAD areas. The results from the statistical comparisons conducted for this study supports the hypothesis that the number of individuals and species identified from the 1999 NBH LTM samples was not significantly different from the 2002 CAD cell results (ENSR, 2003, and see Appendix E).

Annelids (polychaetes and oligochaetes) were the most diverse fauna found at the proposed CAD cell sites and from the Segment 2 corresponding stations. In CI polycheates represented 40%, oligocheates 20%, gastropods 20%, nemerteans 10% and bivalves 10%. The proposed PIN CAD cell site had polychaetes representing 50%, oligocheates 20%, and bivalves 30%. Polychaetes comprised 80% of the top ten fauna at the Segment 2 PIN corresponding sites with oligochaetes and a bivalve species each with 10%.

The Shannon-Wiener diversity calculation (Lloyd *et al*., 1968) characterizes the diversity of a sample or community by a single number (Magurran, 1988). Species diversity involves two components: the number of species, or richness, and the distribution of individuals among species, or evenness. Shannon-Wiener diversity and Pielou's evenness were calculated for the 4 CI and the 4 PIN stations that were analyzed and an average of these parameters was calculated for the corresponding Segment 2 locations. Pielou's calculation for evenness was used for this analysis and evenness can be defined as the distribution of individuals among species or the calculation of the uniformity in species abundance within a certain assemblage (sampling station).

The evenness and diversity at the proposed CI stations was, on average, slightly higher than diversity at the proposed PIN stations but was not statistically significantly different ($t=0.69$, $p<0.05$, $df=6$; $t=0.82$, $p<0.05$, $df=6$, respectively). Average diversity and evenness found at the PIN proposed CAD cell samples were compared with corresponding stations sampled in Segment 2 during the NBH LTM monitoring effort. The results showed higher average diversity and evenness from the PIN CAD cell samples, however, these differences were not significantly different ($X^2=0.03$, $p<0.05$, $df=1$; $X^2=0.06$, $p<0.05$, $df=1$, respectively). A similar trend was observed when the results from the CI proposed CAD cell samples were compared with corresponding Segment 2 station data. The average evenness and diversity were slightly higher at the CI CAD cell sites but not significantly different ($X^2=0.09$, $p<0.05$, $df=1$; $X^2=0.08$, $p<0.05$, $df=1$, respectively).

3.6.4 Summary

From the sediment grain size analysis discussed in section 3.5, sites were comprised of silt and clay with high total organic carbon concentrations. Because contaminants typically bind to finer grain size particles, it is likely that these stations have chemical contamination. PCBs were detected above laboratory detection limits on both CAD sites in the surficial sediment chemistry analyses done for this FEIR (Maguire, 2003, and see Section 3.5) The results from the sediment grain-size analysis conducted as part of this latest survey for the FEIR showed that fine-grained silt and clay were the predominant sediment type found at the PIN and CIN stations and total organic carbon was high. These results agree with those found by the SPI survey in the DEIR conducted in 1999 by MA CZM.

The marine sediment of New Bedford/Fairhaven Harbor is historically contaminated with PCBs, PAHs, and heavy metals (ENSR 2001). Data for sediment chemistry is presented in the 1999 NBH LTM report (ENSR, 2001). Copper concentrations found in the 1999 study ranged between 100 and >1000 ug/g dry weight. Sediment toxicity from the 1999 study was less than 60% survivability at all Segment 2 sites corresponding to the proposed CAD cell locations. This suggests that the sediment in the vicinity of the proposed CAD cell sites is anthropogenically affected.

Composition and dominance of the benthic infauna of samples collected as part of the proposed CAD cell sampling effort (2002) were similar to those reported for the NBH LTM samples taken in 1993 (Nelson *et al*., 1996), 1995 (EPA unpublished data) and 1999 (ENSR, 2001). Polycheates; *Streblospio benedicti*, *Tharyx acutus*, *Leitoscoloplos* spp., and *Mediomastus ambiseta*, Oligochaete; *Oligochaeta spp.*, and Bivalve; *Mulinia lateralis* were the dominant species found at the proposed CAD cell stations. These same species were also found to dominate the benthic infauna of Segment 2 in 1995. Bivalve; *Mulinia lateralis* was very abundant in 1993 and 1999 but not in 1995. If *Mulinia lateralis* is removed from the 1993 and 1999 data then the species composition for these two years is even more similar to the 2002 monitoring results.

Differences in species abundance when comparing the 2002 data with the 1999 results could be attributed to differences in temporal sampling events. The NBH LTM samples were taken in the summer of 1999 while the samples for the monitoring of the proposed CAD cell sites were taken in the fall of 2002. As the water temperature and food supply decrease and storms appear more frequently during the fall the benthic population abundance tends to decrease. Comparison of NBH LTM data with the CAD cell results suggests that the benthic fauna populations remain statistically similar and suggest that community structure hasn't changed over the course of 10 years.

The dominant organisms that comprise the benthic community at the proposed CAD cell sites are classified as pioneering or opportunistic species (Rhoads and Germano, 1982). Pioneering organisms colonize the sediments quickly following a disturbance, and typically include dense aggregations of near-surface living, tube-dwelling polychaetes or opportunistic bivalves (Rhoads and Germano 1982, Santos and Simon 1980a). Stage I lower opportunistic stage assemblages are associated with short-term disturbed environments not unlike the more anthropogenically degraded marine environments of working harbors like New Bedford/Fairhaven or Boston.

The results of the 1999 sediment profile survey demonstrates that the stations sampled within the navigational channel near Popes Island (the same sites that were revised for the benthic community survey in 2002) consisted of fine-grained, silt-clay sediments greater than 4 phi (phi are units of measurements geologists use for sediment). Of the images that were analyzed from this area (PIN and CIN), Stage I species (opportunistic polychaetes) were the predominant successional stage.

Similar opportunistic communities were observed at the Boston Harbor Navigational Improvement Project (BHNIP) CAD cell sites in 1999 (ENSR, 2001). This project included analyzing sites that were dredged, filled and capped as well as ambient localities and unfilled cells using sediment profile image and benthic infaunal analyses. The investigation at the BHNIP CAD cell site showed that, within a year of filling and capping, the opportunistic benthic infauna had re-colonized the sediment surfaces. The SPI survey (1999) and the benthic infaunal analysis (2002) are remarkably consistent with one another. The 1999 spi and 2002 surveys (SAIC, 1999, and ENSR, 2003) provide strong evidence to support the fact that the communities in the Lower New Bedford/Fairhaven Harbor, in the area of the two proposed CAD cell sites, are dominated by opportunistic species that can tolerate disturbed conditions.

It is highly likely that construction, filling, and capping events at the proposed Harbor CAD cell sites will temporarily impact the benthic communities. However, similar to BHNIP cells the CI and PIN cell surfaces will be recolonized rapidly by similar opportunistic species. Eventually, the benthic community will return to a pre-dredging composition. Adults and larvae from adjacent areas, which were not dredged, will provide recruits to the disturbed sites.

3.7 Fisheries Resources

A study conducted by Normandeau Associates Inc. (NAI) for the DEIR from June 1998 to May 1999 characterized the fisheries resources of the Harbor and results are applied to assess the two preferred alternative CAD cell sites between the two preferred alternative CAD cell sites, CI and PIN (NAI, 1999). Within the NAI study, Station NT-4 was located in the CI CAD cell area to the east of the New Bedford docks. Results of sampling at this location represented the fisheries resources of the CI site. Station NT-5 was located in the PIN site.

3.7.1 Goal

The goal of the Harbor fisheries resource study was to provide data that can be used to evaluate the effects of dredging and aquatic disposal on fisheries resources.

3.7.2 Description of Study

Fisheries sampling were conducted from June 1998 through May 1999 on trawl tracks coincidental with the areas of the preferred alternatives. The sampling frequency was bi-weekly from June through October 1998 and May 1999 and monthly from November 1998 through April 1999. A thirty foot bottom trawl with 2 -inch stretch mesh in the body and 1 ½ inch-stretch mesh cod end lined with 1/4 –inch mesh was towed over the tracks for approximately 400 m (NAI, 1999).

3.7.3 Results

3.7.3.1 Channel Inner

At station NT4, the annual geometric mean catch per unit effort (CPUE) was determined to be 25.47 fish per 400 m trawl length. The catch at this station was dominated by cunner, scup, northern pipefish, Atlantic herring, and winter flounder. Scup, Atlantic herring, and winter flounder are species managed by the New England Fishery Management Council (NEFMC). The monthly geometric mean CPUE was highest in March due to a very large catch of Atlantic Herring (n=1,468) and in September due to the large catches of scup (NAI, 1999).

Cunner were captured during each month of sampling except the winter months from December to March. At this time cunner are thought to become inactive or migrate out of estuaries (Able and Fahay, 1998). In the NAI study, CPUE for this species was greatest in November and April. Sampling in April, and again from July to September revealed a recruitment of YOY cunner (i.e., <39mm) to the area (NAI, 1999).

Scup were captured from August to December with the highest CPUE occurring in September. YOY scup (i.e., those <40 mm) were first captured in August. In the Middle Atlantic Bight, they are reported to remain in estuaries until September when they begin migration out of the estuary (Able and Fahay, 1998). Catches of adult scup at NT4 were insignificant. The ingress of YOY scup to bays within the Mid Atlantic Bight is consistent with results of the National Marine Fisheries (NMFS) Marine Resources Monitoring, Assessment, and Prediction (MARMAP) surveys conducted between 1977 and 1987; the findings of Whitting (1995); and those of Whitting, et al. (1999).

Northern pipefish were absent form trawl catches during July, January, February, and May, with the highest occurring from August through November. The majority of pipefish captured were >100 mm. Since the YOY of this species are extremely variable in size (Able and Fahay, 1998) some individuals may have been YOY fish. Within the Mid Atlantic bight, they are reported to leave estuaries by November to winter in deeper oceanic waters of the continental shelf.

Catches of Atlantic herring occurred in January and March with the CPUE varying greatly between the two months (7 to 1,468, respectively). All Atlantic herring captured were YOY less than 50 mm, which is consistent with the findings reported for other estuaries in the Mid-Atlantic bight (Able and Fahay, 1998).

Winter flounder were captured in NT4 trawls during every month except November and December, with the highest CPUE occurring in June and July. Size class analysis of the catch revealed that June trawl captures represented recruitment of YOY fish less than 45 mm, which is consistent with the findings reported for other estuaries in the Mid Atlantic bight (Able and Fahay, 1998).

black sea bass were captured during the August trawl. Although it was not among the five most abundant fish, it is important to note since it is a managed species. Fish captured within the trawl were found to be less than 30 mm. August was the only month black sea bass were captured. This species is reported to spawn during summer months, whereupon the larvae and early juveniles occur in both estuaries and adjacent coastal ocean waters for the remainder of the summer. After summer, they emigrate to deeper ocean waters (Able and Fahay, 1998).

3.7.3.2 Pope's Island North

At station NT5, the annual geometric mean catch per unit effort (CPUE) was determined to be 5.08 fish per 400 m trawl which shows substantially lower abundance at this station compared to the other trawl stations of the Harbor. The catch at this station was dominated, in order of abundance, by winter flounder (52.5 % of the CPUE), seaboard goby (9.5% of CPUE), Atlantic silverside (8.0 % CPUE), bay anchovy (6.5% CPUE), and windowpane (5.7% CPUE). Winter flounder and windowpane are species managed by the NEFMC. The monthly geometric mean CPUE was highest in August and October due to large catches of Atlantic silverside in August (6.18/trawl) and winter flounder in October.

Winter flounder were captured in trawls every month except July. Abundance peaked in October and remained high through December. YOY winter flounder recruitment appeared to occur in November when fish less than 100 mm were captured but were absent from trawls during other months. No recently settled flounder (<30 mm) were captured at Station NT5.

Seaboard goby, the second most abundant fish captured in the trawls at NT5 were all less than 52 mm and were only captured in November and December (NAI, 1999). Seasonal migration patterns and behavior of this fish have not been reported or described and it has been found in Mid Atlantic Bight estuaries during summer months (Able and Fahay, 1998). The reason for its appearance at NT5 only during the November and December months is unknown at this time.

Atlantic silverside, the third most abundant fish species captured in the trawl at NT5 were captured only in August and October; these fish being less than 86 mm. The smallest (27 mm) were captured in August. The pattern of abundance was consistent with other studies in the region (Hoff and Ibara, 1977; Ayvazian, et al., 1992)

Bay anchovy, were captured in August and September. The catch of this species was composed primarily of YOY less than 30 mm. The annual production of this species has been know to be of such magnitude that YOY may easily influence or dominate the total fish production of an estuary (Able and Fahay, 1998).

Windowpane were captured in September, October, and December. The catch of windowpane was composed of a mixture of YOY and yearlings, lending evidence to the possibility that New Bedford Harbor may provide a nursery for both spring and fall spawned windowpane.

3.7.4 Summary

3.7.4.1 Channel Inner

The fish community represented by Station NT4 was similar in composition to three additional trawl stations located within the Outer Harbor which were sampled as part of the same study (NAI, 1999). In addition, many of the fish species at Station NT4 exhibited similar patterns of abundance and recruitment patterns similar to those exhibited by the same species in the DMF nearshore (i.e., < 9m depth) trawl sampling data set for Buzzards Bay available from 1978-2000 (Carey and Haley, 2002). Despite the fact that the habitat found within New Bedford’s Inner Harbor proximal to the Channel Inner site is considered degraded, it supports an ichthyofaunal composition similar to that of nearby, less disturbed estuaries. It provides nursery habitat for important recreational and commercial fish species such as scup, black sea bass, cunner, and winter flounder. The lack of presence of winter flounder in NT4 trawls for the months of November and December may be an indication that they had moved upstream. Bigelow and Shroeder indicate that in shallow enclosed harbors, winter flounder tend to desert shallow sun-warmed waters over flats in summer for deeper harbor basins. Conversely, these flatfish tend to return to the shoals over the flats in cooler moths of fall and winter (Bigelow and Shroeder, 1953) They are at their spawning peak from January to May in New England, and during February and March south of Cape Cod (Bigelow and Shroeder, 1953).

3.7.4.2 Pope's Island North

The fish community represented by Station NT5 differed in composition from NT4 and other deep water trawl stations located within New Bedford Outer Harbor, as well as the fish community and recruitment patterns represented by DMF trawl captures represented by data available from 1978-2000 (Carey and Haley, 2002). Despite the fact that the habitat found within New Bedford’s Inner Harbor proximal to the Pope’s Island North site is considered degraded, it provides nursery habitat for winter flounder and windowpane. However in contrast to both the lower reach of the Inner Harbor and the Outer Harbor, the ichthyofaunal community of the upper reach of the Inner Harbor (i.e., north of Pope’s Island) as represented by trawl sampling at NT5 is dominated by less number of managed species, has a less diverse finfish community, and is relatively less productive for important commercial and recreational finfish species such as scup, black sea bass, and cunner. However, it is still an important nursery for winter flounder and windowpane and is a productive area for smaller prey species such as Atlantic silverside, bay anchovy, and seaboard goby. Winter flounder are noted as peculiar in that their eggs are not buoyant (Bigelow and Shroeder, 1953, and Able and Fahey, 1998). Eggs hatch in between two and three weeks and larvae develop in between 2.5 to 3.5 months (Bigelow and Shroeder, 1953). Larvae are thought to not occupy the surface waters, but rather the bottom (Bigelow and Shroeder, 1953 and Able and Fahey, 1998). Larval winter flounder tracked in a Mystic River Connecticut study were found most common from March to June earlier in the upper estuary and later in the lower estuary (Able and Fahey, 1998).

3.8 Water Quality Studies

Water column chemistry studies were important to the completion of the Harbor FEIR due to levels of chemicals in harbor bottom sediments that might have effects on dredging permitting. Surface water samples were collected for elutriate testing and for background analysis. Water quality thresholds studies were conducted to provide a proven approach to the establishment of toxic chemical concentrations in site-specific Harbor water for Water Quality Certificate requirements necessary for permittable CAD cell construction and related Harbor dredging. In this section of the FEIR, the surface water study will be presented first followed by the water quality thresholds study.

3.8.1 Goal of Surface Water Study

Surface water was analyzed to determine site-specific background water chemistry and turbidity values for the proposed alternatives CI and PIN.

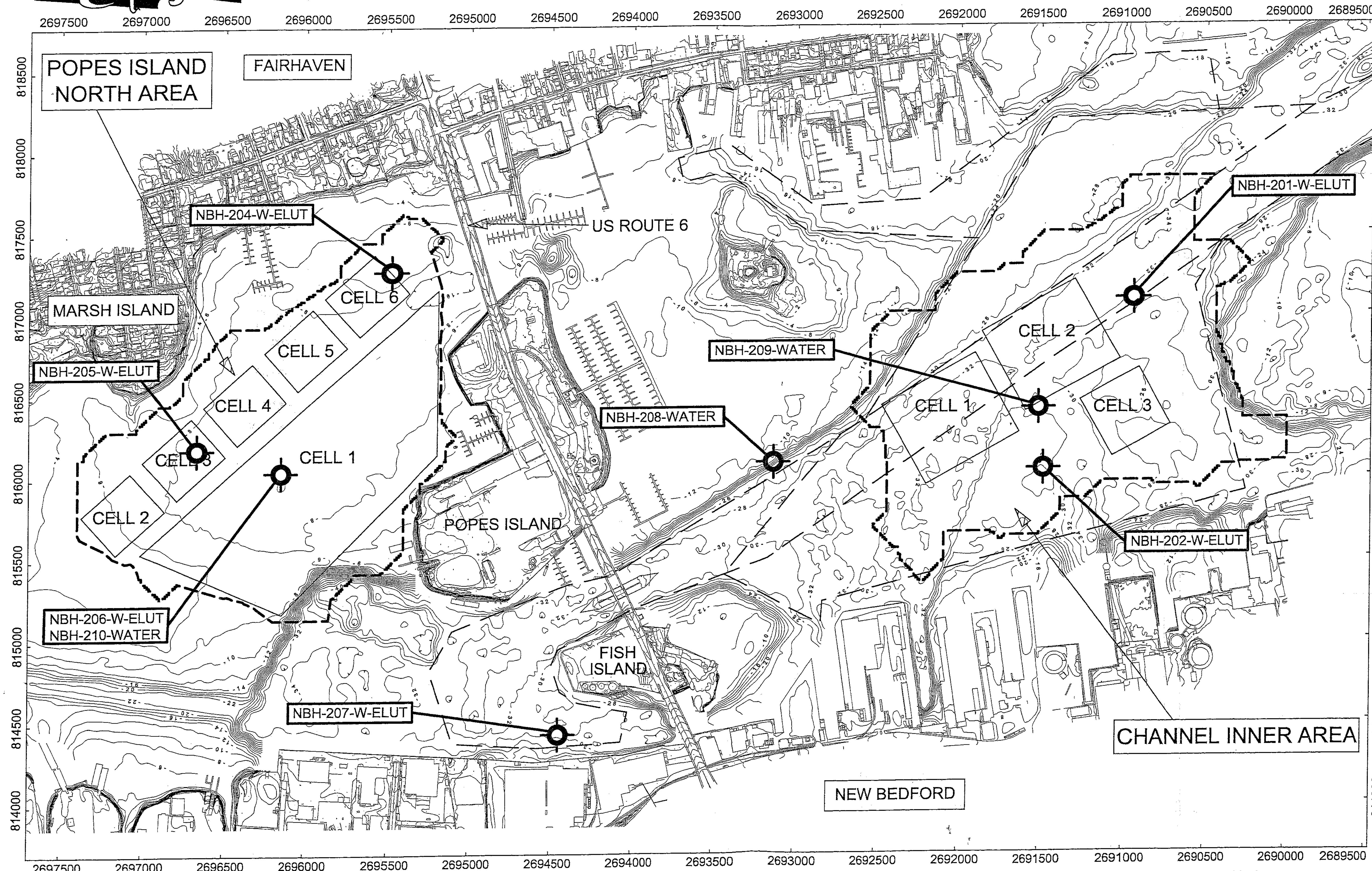
3.8.2 Description of Surface Water Study

On October 21, 2002, surface water in three locations was field screened at various depths for pH, conductivity, turbidity, dissolved oxygen, temperature, salinity, total dissolved solids, and oxidation reduction potential (Figure 3-19). Table 3-3 presents a summary of these surface water-screening results. The parameters obtained during the sampling indicate a relatively homogeneous environment with depth. If values had changed with depth, a stratification effect would have been assumed to be present. This was not the case with the information obtained during the surface water screening. The measurements obtained during the screening activities were compared to the Surface Water Quality Standards (SWQS) as presented in 314 CMR 4.00.

Surface water samples were also collected from the RV Cyprinodon, on October 10th and 21st, 2002. The first marine water samples were collected concurrently with vibracore activities. For the second set of surface water samples, three locations were field screened at various depths for pH, conductivity, turbidity, dissolved oxygen, temperature, salinity, total dissolved solids, and oxidation reduction potential to support detailed CAD cell dredging and event modeling and hydrodynamic analyses. Surface water sample NBH-208-Water was submitted to a USACE-certified laboratory for analysis of COD, BOD, total solids, RCRA (8)metals plus nickel, copper, lead, organochlorine pesticides, PAHs by EPA Method 8270, PCB Congeners by Method 8082, and TOC by Lloyd Kahn Method. The surface water sample was delivered to a certified laboratory on October 22, 2002.

Table 3-6. Surface Water Parameters

	Location						
Parameter	**NBH-208-Water**		**NBH-209-Water**			**NBH-210-Water**	
UTM Coordinates	816,092 mE 2,693,135 mN		816,420 mE 2,691,507 mN			816, 041 mE 2,696,149 mN	
Depth in meters	6	3	9	6	3	3	1.5
pH	5.62	5.78	5.90	5.91	5.92	6.11	6.05
Conductivity in µS/cm	42.3	42.2	42.5	42.3	42.3	37.0	42.0
Turbidity in NTU	-10	-4.7	-7.7	-5.4	-6.0	-10	-4.5
Dissolved Oxygen in mg/L	6.13	6.17	6.32	6.28	6.29	6.68	6.37
Temperature in °C	13.77	13.76	13.75	13.76	13.81	13.84	13.89
Salinity (%)	2.7	2.7	2.7	2.7	2.7	2.5	2.7
Total Dissolved Solids in g/L	26	26	26	26	26	23	26
Oxidation Reduction Potential in mV	101	96	89	85	84	-120	54
Notes:	Depth in meters is Depth below Water Surface						



NOTES:

1. Base Plan of the New Bedford Harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).

SURFACE WATER SAMPLING LOCATIONS AT CHANNEL INNER AND POPE ISLAND NORTH CAD CELL SITE AREAS

0 600 1200 1800

SCALE: 1"=600' FEET

LEGEND & ABBREVIATIONS

SAMPLING LOCATION

ELUT = ELUTRIATE
MAC = GRAIN SIZE AND T.O.C.
SED = CHEMISTRY

CZM

Maguire Group Inc.
Architects/Engineers/Planners
225 Foxborough Boulevard
Foxborough, Massachusetts 02035

MAGUIRE GROUP

NEW BEDFORD/FAIRHAVEN HARBOR DMMP FEIR

FIGURE 3-19. SURFACE WATER SAMPLING LOCATIONS AT CHANNEL INNER AND POPES ISLAND NORTH CAD CELL SITE AREAS

PROJECT NO.: 16454	
DESIGNED BY:	---
DRAWN BY:	---
CHK'D BY:	
DATE:	06/02/03
SCALE: AS NOTED	

3.8.3 Results of Surface Water Study

PAHs, organochlorine pesticides, and dioxins were not detected above laboratory quantification limits in the surface water sample NBH-208-WATER. Arsenic, lead, selenium, and zinc were detected at concentrations of 4.2 µg/L, 4.7 µg/L, 2.3 µg/L, and 53 µg/L, respectively. Total solids, BOD, COD, and total organic carbon were respectively reported as 3.6%, 3.6 mg/L, 4,200 mg/L, and 1.6 mg/L.

The sampling areas of the preferred alternatives CI and PIN were observed to be free from floating, suspended and settleable solids. Excessive solids typically cause aesthetically objectionable conditions, and may potentially impair the benthic biota or degrade the chemical composition of the bottom. Although the turbidity readings were influenced by the sunlight, no visual evidence of color or turbidity abnormalities were present in the sampling areas. There were no observations of any visible sheen from oil, grease or petrochemicals the water surface.

The water quality classification of the Inner Harbor is Class SB, due to the presence of combined sewer overflows. The levels of measured dissolved oxygen were above the SWQS of 5.0 mg/L for Class SB Coastal Marine Water Body. The negative values for turbidity are likely due to sunlight interference. Since the range of pH values for class SB is between 6.3 and 8.3, the detected pH values of the sample set were not more than 0.5 units outside of the background range. Original laboratory data, laboratory QA/QC, methods, and the chain-of-custody form are included in Appendix D.

3.8.4 Summary of Surface Water Study

Surface water was collected from preferred alternative site-specific locations and one control location in the Harbor and samples were analyzed at a certified testing laboratory to detect any hazardous levels for chemical concentrations of concern. No laboratory detections appeared above laboratory quantification limits. The parameters tested for surface water quality indicate a relatively consistent, homogeneous setting with depth.

3.8.5 Goal of Water Quality Thresholds Study

The goal of this water column chemistry study is to determine if ambient water quality conditions influenced by resuspended sediment and chemicals from dredging operations of the preferred alternatives will be less restrictive to these operations than default water quality criteria. Site-specific allowable chemical concentrations values, protective of Harbor aquatic life, will then be applied to predictive dispersion modeling. Ultimately, the incorporation of these protective chemical concentrations values in the predictive dispersion modeling will be helpful to establishment of permitting thresholds important to CAD cell permit applicants, contractors, regulators and CAD cell managers.

3.8.6 Description of Water Quality Thresholds Study

The thresholds study was conducted for the proposed CI and PIN CAD cell areas. CAD cell construction activities typically result in resuspension and release of dissolved and particulate constituents into the water column. Resuspension of dredged sediments lead to contaminant concentrations that exceed thresholds posed by published ambient water quality criteria (WQC). The development of water quality standards or thresholds prior to dredging and disposal actives will provide target baseline conditions, which are not to be exceeded during operations. Failure to meet these thresholds will trigger avoidance and minimization responses to ensure that water quality conditions and marine resources within New Bedford/Fairhaven Harbor are not compromised.

Site-specific water quality thresholds were established through a set of three progressive water column chemistry studies with mysids and sea urchin larvae. Capsule summaries of the three progressive water quality studies are presented below; They include the Site Specific Water Quality Assessment Study (WQA), Suspended Particulate Phase (SPP) and Water-Effect Ratio (WER).

1. *Suspended Particulate Phase (SPP)/*elutriate testing assessed the bio-availability of measured chemical concentrations from field samples through aquatic toxicity testing, and compared these results with the default water quality criteria. SPP toxicity was observed and triggered toxicity identification evaluation of site-specific samples.

2. *Toxicity Identification Evaluation (TIE)* testing (US EPA, 1994) was conducted to determine if the source(s) of toxicity are attributable to metals, organics or confounding factors (e.g., suspended solids; ammonia). Site-specific toxicity was observed and triggered the water-effect ratio study.

3. *A "Water-Effect Ratio" (WER)* was used to derive *site-specific protective limits* that would be less restrictive than default WQC values for application beyond the mixing zone. This adjustment was obtained through laboratory testing, as prescribed by the EPA Water-Effect Ratio method (US EPA, 2001;1994).

3.8.7 Results of Water Quality Thresholds Study

3.8.7.1 SPP

Only elutriate test results conducted in an area of Channel Inner (NBH-202) demonstrated toxicity to one of the test organisms (mysids). For NBH-202, toxicity was observed in the 100% SPP, but not in any of the dilution series. Although the absence of toxicity in the dilutions for this sample indicates a relatively low level of toxicity, the toxicity required further evaluation utilizing toxicity identification evaluation (TIE) and water effects ratios (WER) to resolve potential source of the observed toxicity. Ammonia concentrations measured as a routine practice at the start of SPP testing indicate that NPH-202 had the highest concentration of total and unionized ammonia.

3.8.7.2 TIE

In the TIE study, results the analyses of the chemical exposures suggest that both copper and PCB concentrations are in the exposure range were toxicity could occur, depending on species sensitivity and site-specific water quality conditions. TIEs are used to identify cause and effect relationships between toxicity observed in toxicity tests and factors that have contributed to the observed effects. These relationships are revealed through the through manipulations that remove the toxicity of individual contaminant classes (e.g., metals, organics, or ammonia). Specific Hazard Quotients and TIE results generally both support the finding of multiple sources of toxicity. Copper and ammonia toxicity to one of the test organisms (sea urchins) appeared to have exceeded the capacity of the TIE treatment to sufficiently limited observed effects.

The *Ulva* treatment was applied to clear ammonia. For mysids, the concentration of ammonia added indicates that *Ulva* treatment had no adverse affect on survival. For the sea urchin, the *Ulva* treatment did not improve larval development, indicating that the treatment did not reduce ammonia to a non-toxic level *Ulva* treatment of the NB-202 site sample was performed to remove ammonia as a source of toxicity. In the NBH-202 sample, *Ulva* completely removed toxicity to mysids. Another test organism (mysids) was most affected by PCBs and ammonia, but their sensitivity to copper appears to increase with near toxic levels of PCBs. Associated reductions in toxicity are used to characterize causative factors. It was expected that the cause of acute toxicity in NHH-202 (Channel Inner) would be principally due to copper, PCBs, and compounding factors.

The role of PCBs was determined to be uncertain for the three toxicants due to the need to use toxicity values derived for specific PCB mixtures (e.g., Aroclor 1242) that are different from the mixture presented in the NBH sediment sample.

3.8.7.3 WER

The toxicity of contaminants can be altered by site-specific biogeochemical factors. One approach outlined by USEPA is the derivation of site-specific water quality criteria for contaminants involves the development of WERs (SAIC, 2003, and see Appendix I). This approach entails multiplying national water quality criteria by an experimentally derived WER where the WER is defined as the ratio of the toxicity of a contaminant in the site water to the toxicity of the same contaminant in standard lab water. General equations depicting this relationship is presented below:

WER = LC50 (site water threshold value) / LC50 (lab water threshold value)
WER x AWQC= Site specific criterion
Note: LC50 = Lethal Concentration, 50%

3.8.8 Summary of Water Quality Thresholds Study

The SPP elutriate testing and the TIE indicate that acute exposure to copper was likely the most limiting water quality factor in instantaneous releases of dredged material. This water quality study utilized a test organism (sea urchins) that is sensitive to copper to determine a WER for the most limiting water quality factor associated with dredged material from New Bedford Harbor upon the instantaneous release of sediments to the proposed CAD cell sites. When the WER is applied to published water quality standards it will allow less restrictive site-specific water quality thresholds by broadening the standards based mixing zone limits and reducing the area of toxic impact to organisms. WER methodology used in this study is as prescribed by the EPA Water Effect-Ratio (US EPA, 2001;1994). DEP will set the water quality thresholds in response to dredging project applications.

See Section 5.0 for a discussion of the application of the Thresholds Study to water quality modeling and the determination of an appropriate mixing zone.

3.9 Hydrodynamics

In the DEIR a hydrodynamic analysis was conducted based on previous studies and existing literature (Maguire, 2002). The DEIR suggested and the DEIR Certificate concurred that site-specific hydrodynamic analysis should be conducted for the FEIR. A field program was conducted from October 23, through November 22, 2002 to monitor present hydrodynamic conditions of the Harbor relative to CI and PIN. Hydrodynamic conditions for the two proposed preferred alternative CAD site areas in relation to one control location near the hurricane barrier were monitored for a full diurnal tidal cycle for the purpose of sediment resuspension and instantaneous chemical release modeling (ASA, 2003, and section 5-0). The hydrodynamic modeling examined physical field data (surface elevations and velocities) to identify primary force that drive the circulation in New Bedford Harbor, which were characterized as nine typical Harbor scenarios of winds and tides. These nine hydrodynamic conditions were used to provide three dimensional velocity predictions to the contaminant and sediment transport model before and after the dredging excavation activity of the Popes Island North CAD facility.

3.9.1 Goal

The primary goal was to collect hydrodynamic field data for detailed hydrodynamic conditions characterizations. These field data included Harbor and site-specific information on tides (sea surface elevation) and currents (horizontal current strata throughout the water column). The secondary goal of hydrodynamic study was to simulate characteristic circulation patterns in New Bedford Harbor for use in the subsequent pollutant and sediment transport modeling Section 5-0.

3.9.2 Description of Studies

Tide and current data were collected for use in the hydrodynamic calibration, sediment physical samples were obtained for use in the dredging modeling, and elutriate concentrations of sediment contaminants were collected to determine source strengths for the fate and transport modeling.

Current speed and direction, surface elevation and optical backscatter were measured continuously throughout the study period at two locations in New Bedford Harbor: the Popes Island and Channel Inner stations. This was accomplished through the deployment of Acoustic Doppler Current Profilers (ADCPs) and Acoustic Doppler Current Meters (ADCMs) at each of these two locations. Surface elevation and optical backscatter were also monitored at the Tide Gauge station, located outside of New Bedford Harbor, using a tide gauge and an Optical Backscatter Sensor (OBS).

3.9.2.1 Tides

Variations in sea surface elevation were measured at three stations within the study area. Pressure gauges on the ADCMs deployed at the Popes Island and Channel Inner stations recorded total pressure from the water column and atmosphere at 15-minute intervals. These data were corrected for atmospheric pressure and then demeaned to give variations relative to mean sea level. Sea surface elevation was measured outside of New Bedford Harbor at the Tide Gauge station. A tide gauge was used to record total pressure due to atmospheric pressure and water column height at 15-minute intervals. As with the ADCMs, these data were corrected for atmospheric pressure and demeaned to give variations relative to mean sea level.

3.9.2.2 Currents

Horizontal currents were measured throughout the water column at the Channel Inner and Popes Island stations using ADCPs from RD Instruments. A 600 kHz instrument, with a bin size of 0.50 m (1.6 ft), was used in the deeper waters at the Channel Inner site, while 1200 kHz instrument was used at the Popes Island site, with a bin size of 0.25 m (0.8 ft). The ADCPs recorded velocities at 15 minute intervals. The resulting data was subsequently low-pass filtered using a 5-hr window. To better resolve currents near the bottom, an Aquadopp ADCM was deployed in conjunction with each ADCP. Positioned approximately 0.6 m (2 ft) above the seafloor, or about one third of the distance to the first bin of ADCP data, the ADCMs recorded velocities at the bottom of the water column at 15 minute intervals. These data were low pass filtered with a 5-hr window.

The net flow of water at a given location can be estimated by considering the average current velocity over the entire depth of the water column. Depth-averaged currents at the Popes Island site were predominantly to the southeast during the study period, though periods of flow to the north did occur during flood tides. Depth-averaged currents had a mean speed of 2.3 cm/s (0.08 ft/s) to southeast, with a maximum value 15.0 cm/s (0.49 ft/s) during this period.

3.9.3 Hydrodynamic Modeling

WQMAP, as the model system is known, uses a three dimensional boundary fitted finite difference hydrodynamic model (BFHYDRO) developed by Muin and Spaulding (1997a and b). The model has undergone extensive testing against analytical solutions and used for numerous water quality studies. The grid system used in the boundary-fitted coordinate model system is unique in that grid cells can be aligned to shorelines and bathymetric features (like dredged channels) to best characterize the study area. In addition, grid resolution can be refined to obtain more detail in areas of concern. This gridding flexibility is critical in representing the New Bedford Harbor waters where geometry is highly variable and complex.

3.9.4 Surface Wind Stress

Two wind data sets from New Bedford Municipal Airport (~5.3 km [3.3 mi] north-west of Popes Island) and Buzzards Bay NOAA Buoy (~29 km [18 mi] south-south-west of Popes Island) were considered. During the period of the field program, their directions were nearly identical, but speeds at the buoy were substantially larger. Although the NOAA Buzzards Bay Buoy provided a better estimate of the unobstructed wind, the wind record from the airport was selected because of its proximity to the Inner Harbor.

3.9.5 Results

3.9.5.1 Combined Forces Drive Hydrodynamic Conditions

The elevation and velocity spectrum distributions reveal that tides and winds are the primary causes that drive circulation in the region. This observation can also be inferred by examining the variations of elevation and velocity in time. Figure 3-21 shows observed winds (New Bedford municipal airport), elevation (outside of the Hurricane Barrier) and velocities (Channel Inner and Popes Island North) together on the same time axis. All forces drive the circulation with their own frequencies or random times: half daily tidal cycles, spring-neap fortnightly cycles and episodic wind events. Although the variation of velocities is very complex, the response to wind is particularly noticeable through time. Velocities in Figure 3-21 are shown for surface, vertically averaged, and bottom. At the CI station, with a 9.2 m (30 ft) water depth, the surface and bottom velocities are quite different. The surface velocities are larger, more variable, and generally flow to the south, while bottom velocities are smaller and show an oscillating north-south direction. Velocities at PIN, with a 2.6 m (8.5 ft) water depth, are more uniform vertically with somewhat higher speeds t the surface than at the bottom.

In general, typical driving forces in normal estuarine circulation are tide, wind, and density gradient. Tide and wind influence are clearly seen in the observations. The significance of the density gradient is based on freshwater inflows. If the amount of freshwater inflow is small relative to the estuary size, the density gradient is not expected to play a significant role. The evidence of density gradients can be seen in the longitudinal salinity. No salinity observation were made for the period of field investigation, but other studies concluded the density driven flow would be much less than 1 cm/s (see the discussion in Abdelrhman [2002]) south of Coggeshall St./I-95 Bridge, the lower portion of the Inner Harbor where the dredging and disposal operations are planned.

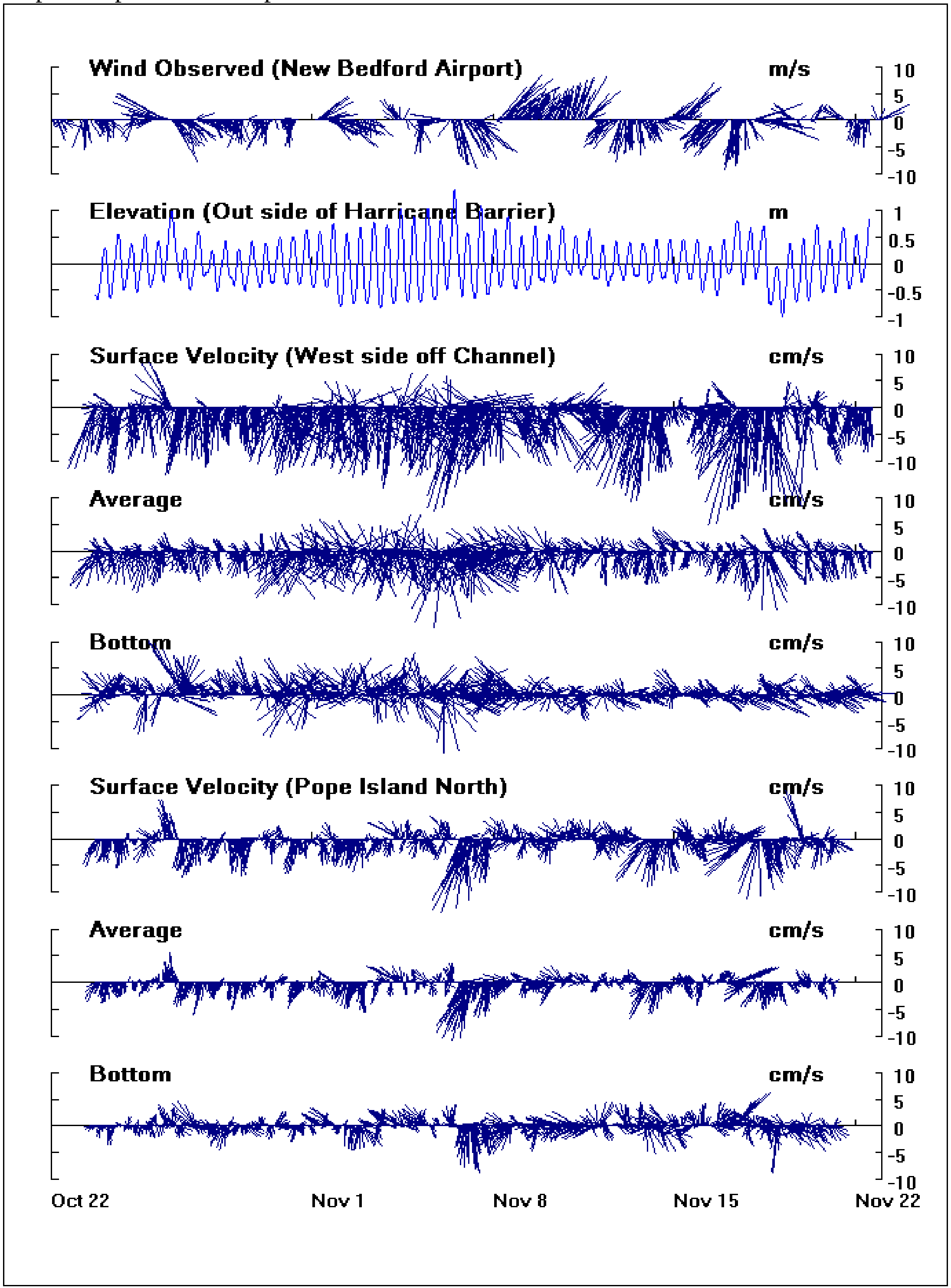


Figure 3-20. Time series stack plot of observed wind, elevation and velocity data.

3.9.6 Hydrodynamic Model Simulation Results

The hydrodynamic model simulated the circulation from 20 October to 20 November 2002, the period of the field program, with aforementioned model inputs and parameters. There was very little elevation gradient between Buzzards Bay and the Outer Harbor. Simulated elevations at Channel Inner and Popes Island are in good agreement in amplitude, but their phases slightly lead the observations.

When the observed data was compared with the simulated magnitudes of the velocities, it agreed well with the observations at the Channel Inner and Popes Island North stations, respectively. The flow directions, however, differed in various degrees during the simulation period. The apparent complexity is due to wind stress. During some periods, the currents strongly correlated with the wind. For example, during the period (Oct 24 – Oct 30), wind blew steadily from the NNW direction. The simulated current showed the surface currents were always positively correlated with the wind.

3.9.7 Characteristic Circulation Scenarios

The analysis of the field observations and hydrodynamic simulations confirmed that the major forces driving the circulation in New Bedford Harbor are astronomic tides and winds. The approach taken here was to develop a set of circulation scenarios that reflected most likely conditions. These scenarios were comprised of various tidal conditions and most probable wind conditions. Tidal variations considered were spring, mean and neap tides. Spring tides are the highest high tides and lowest low tides equating to the greatest sea surface elevation difference. Neap tides are the lowest high tides and the highest low tides equating to the least sea level difference. Unlike the astronomic tide, which is predictable, wind is very episodic.

3.9.8 Wind Climate for Inner New Bedford Harbor

The variability of the wind at the New Bedford Municipal Airport was examined. Figure 3-22 and Table 3.7 shows the seasonal probability of wind direction in 30° increments. The compass bearings used in this study were provided from NOAA in a scientific format slightly different than the common 360° compass card. Two prominent wind directions found were south-west-south (SWS) and north-west-west (NWW). Nearly 50% of the time wind blew from the SWS direction in summer and the NWW direction in winter. This tendency remained to a lesser degree during spring and autumn. The probability that wind speed was less than 3.0 m/s (6.7 mph), considered as calm wind, is ~10.7% on average.

Table 3.7. Variations of winds at New Bedford Municipal Airport by season.

	Chance wind blows from either SWS or NWW	**Calm wind (<3.0 m/s)**
Winter	45.5%	8.4%
Spring	35.4	11.1
Summer	50.9	13.8
Autumn	35.3	10.1

Wind speed was quite variable during the seasons. The average wind speed for both directions (excluding the calm wind period) was calculated to be 8.2 m/s (18.3 mph).

3.9.8.1 Circulation Scenarios

Three tidal conditions (neap, mean, and spring) and three wind conditions (calm, SWS, NWW at 8.2 m/s speed) were combined to make the nine circulation scenarios summarized in Table 3.8.

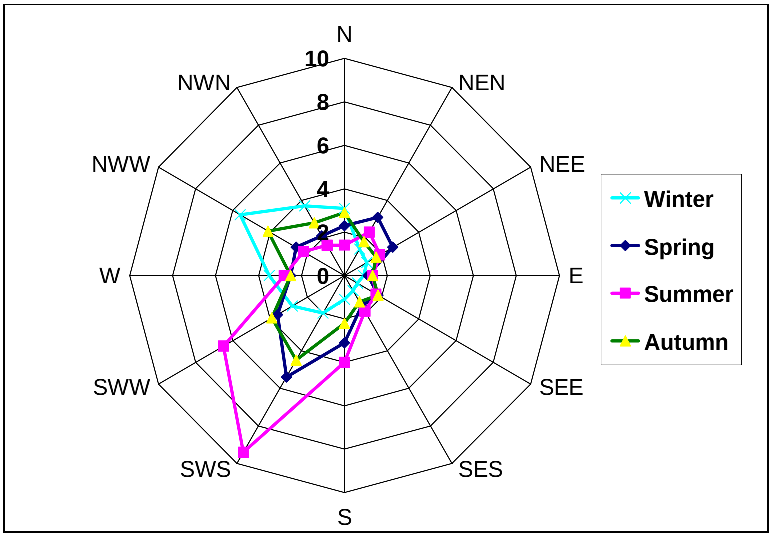


Figure 3-21. Probability of wind direction of the four seasons.

Table 3.8. Circulation scenarios based on tide and wind conditions.

Circulation Scenario	Tide Range	Wind
1	Neap (0.7 m [2.3 ft])	Calm
2	Mean (1.0 m [3.3 ft])	calm
3	Spring (1.4 m [4.6 ft])	calm
4	Neap (0.7 m [2.3 ft])	SWS 8.2 m/s
5	Mean (1.0 m [3.3 ft])	SWS 8.2 m/s
6	Spring (1.4 m [4.6 ft])	SWS 8.2 m/s
7	Neap (0.7 m [2.3 ft])	NWW 8.2 m/s
8	Mean (1.0 m [3.3 ft])	NWW 8.2 m/s
9	Spring (1.4 m [4.6 ft])	NWW 8.2 m/s

To assess the direct effect of tidal conditions and winds, hydrodynamic simulations were run separately for each component. As the tide range doubles from neap to spring conditions, the velocity also approximately doubles throughout the region. There is a strong surface flow heading downwind but modulated by the Inner Harbor geometry. The bottom flow is much lower in magnitude. Simulation results driven by the NWW wind and mean tide showed surface flow again downwind with a significant upwind flow along the bottom in the channel.

Nine hydrodynamic simulations using the combination of tide and wind conditions were then simulated. Table 3.9 compares the simulated speed (vertically averaged) at the two field stations. The result indicates flows driven only by tides are very weak, varying from 1.4 to 4.3 cm/s (0.046 to 0.14 ft/s). Wind substantially increases flow velocities, the SWS wind generating a range of speeds between 5.1 and 9.6 cm/s (0.17 to 0.32 ft/s) and the NWW wind generating a range of speeds between 6.5 and 15.7 cm/s (0.21 to 0.52 ft/s).

Table 3.9. Vertically averaged simulated speed at two field station locations for the nine circulation scenarios.

Circulation Tide	Scenario Wind	Channel Inner Speed (cm/s)	Popes Island North Speed (cm/s)
Neap	Calm	2.1	1.4
Mean	Calm	3.0	1.9
Spring	Calm	4.3	2.6
Neap	SWS @ 8.2 m/s	5.1	9.6
Mean	SWS @ 8.2 m/s	6.0	9.3
Spring	SWS @ 8.2 m/s	7.1	9.4
Neap	NWW @ 8.2 m/s	13.6	6.5
Mean	NWW @ 8.2 m/s	14.6	7.0
Spring	NWW @ 8.2 m/s	15.7	7.5

3.9.9 Summary

New Bedford Inner Harbor is morphologically complex due to two contractions at the Coggeshall St. and I-95 bridges in the upper estuary and it is semi-enclosed by the Hurricane Barrier at its southern end, connecting to the Outer Harbor with a 46 m (150 ft) wide opening. The hydrodynamics are hence complicated, exhibiting circulation governed by both winds and tides. Winds in the area are distinct by season, northwesterly in winter and southwesterly in summer. The currents in the Inner Harbor are dominated by semi-diurnal tides, on the order of 10 cm/s (0.2 kt). A small tributary at the north end of the Inner Harbor is the Acushnet River. Its annual average flow is 0.54 m^3/s (19.1 ft^3/s) (Abdelrhman and Dettmann, 1995). This discharge is too small to play a role in flushing of disposed materials.

The field-obtained elevations and velocities were examined to determine that tides and wind were the primary forces that drove the circulation in New Bedford Harbor. Hydrodynamic simulations were successfully conducted to verify model performance for the period of the field measurement program. Nine basic hydrodynamic conditions were prepared to provide the advection data that will be shown applied to pollutant and sediment transport models (ASA, 2003, and section 5-0) based on the combination of three tidal ranges (neap, mean and spring) and three most likely wind conditions (calm, southwesterly and northwesterly directions). In general, surface and shallow waters tend to move with the wind while flows in deeper areas adjust by compensating the flow to balance the direct wind-induced flows.

3.10 Human Uses

As detailed in the DEIR, existing commercial navigation in the harbor is largely divided into three primary categories:1) traffic related to commercial fishing, 2) fish processing industry and, 3) other maritime vessels and recreational boats (Maguire, 2002). Since the publication of the DEIR in June 2002, the New Bedford Harbor Development Commission has developed elements of the Harbor Plan especially regarding the State Pier and Fish Island. It is important to present new information on the increased commercial vessel traffic relative to the NBHDC developments on the proposed preferred alternative CAD cell sites CI and PIN, respectively.

3.10.1 Recent Harbor Developments Related to Navigation and Shipping

Since the publication of the DEIR, the City of New Bedford under the auspices of the New Bedford Harbor Development Commission (NBHDC) have completed maintenance dredging of the slip to the south of State Pier, the fairways leading thereto and a portion of the federal navigational and maintenance channel immediately northwest of the proposed CI CAD cell area (Apex, 2002).

The largest cruise ship ever to dock in the Harbor, 611 feet long by 79 feet wide, the Regal Empress, docked at the State Pier in summer 2002 (Kalisz, 2002). A total of thirty cruise ships were due to dock at the State Pier over 2002. In August 2004 a high-speed ferry is set to begin service between the State Pier and Martha's Vineyard (Providence Journal, 2003). The new high speed ferry operators expect to run as many as ten trips per day which could equates to as many as 20 Harbor passages per day, possibly some in darkness. The State Pier is located on the New Bedford waterfront just north west of the proposed alternative CI CAD cell site area, and well south of the other proposed alternative PIN CAD cell site area.

Deep-draft commercial fishing vessels as long as 150 feet have been servicing the new herring and mackerel processing plant located on Fish Island north of the CI area and south of the PIN CAD cell area (Commercial Fisheries News, 2002). This new small pelagic fish processing plant is expected to hire 75 employees at current capacity. The Fish Island processing plant is located on the New Bedford waterfront north of the proposed alternative CI CAD site area and south west of the proposed alternative PIN CAD cell area.